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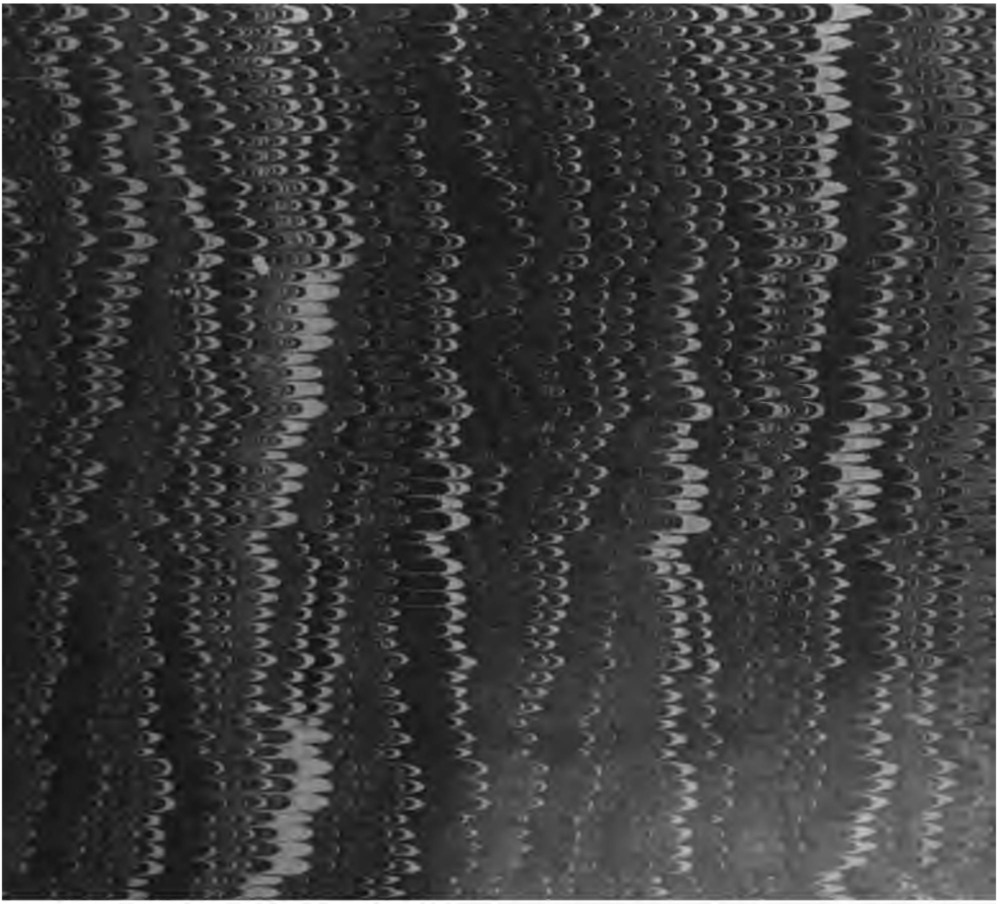

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# ANNUAL REPORT

OF THE

117671

# SECRETARY OF WAR

FOR

# THE YEAR 1891.

IN FIVE VOLUMES.

VOLUME III.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1892.

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# REPORT OF THE CHIEF OF ORDNANCE.

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WAR DEPARTMENT, ORDNANCE OFFICE,
*Washington, October* 1, 1891.

SIR: I have the honor to submit the following report of the principal operations of the Ordnance Department during the fiscal year ended June 30, 1891, with such remarks and recommendations as the interests of this branch of the military service seem to require.

The fiscal resources and expenditures of the Department during the year were as follows, viz:

| | |
|---|---|
| Amount in the Treasury to the credit of the appropriations on June 30, 1890 | $3,994,484.65 |
| Amount in the Treasury not reported to the credit of the appropriations on June 30, 1890 | 452.98 |
| Amount in Government depositories to the credit of disbursing officers and others on June 30, 1890 | 577,091.40 |
| Amount of appropriations for the service of the fiscal year ended June 30, 1891 | 5,882,942.77 |
| Amounts refunded to ordnance appropriations in settling accounts during the fiscal year ended June 30, 1891 | 192,368.49 |
| Gross amount received during the fiscal year ended June 30, 1891, from sales to officers; from rents; from collections from troops on account of losses of or damage to ordnance stores; from Chicago, Rock Island and Pacific Railroad Company; from powder and projectiles (proceeds of sales); from sales of condemned stores; from testing machine, and from all other sources not before mentioned | 63,414.67 |
| Total | 10,710,754.96 |

| | |
|---|---|
| Amount of expenditures during the fiscal year ended June 30, 1891, including expenses attending sales of condemned stores, exchange of powder, etc | 2,688,486.82 |
| Amount deposited in Treasury during the fiscal year ended June 30, 1891, as proceeds of sales of Government property | 40,112.25 |
| Amount turned into the surplus fund on June 30, 1891 | 5,184.89 |
| Amount in Government depositories to the credit of disbursing officers and others on June 30, 1891 | 540,378.99 |
| Amount transferred from ordnance appropriations in settling accounts during the fiscal year ended June 30, 1891 | 1,438.49 |
| Amount in the Treasury not reported to the credit of appropriations on June 30, 1891 | 662.24 |
| Amount in the Treasury to the credit of appropriations on June 30, 1891 | 7,434,491.28 |
| Total | 10,710,754.96 |

### PURCHASING SUPPLIES.

All supplies for the Ordnance Department are purchased after inviting bids by due public advertisement in accordance with the requirements of the act of Congress approved March 2, 1861. When the quantity of supplies is large enough to attract the attention of dealers and manufacturers, this method is usually of advantage to the Government in stimulating competition among bidders and thus securing supplies of standard quality at fair prices. But in the case of small purchases or of the ordinary supplies, when the quantity is small and the value inconsiderable, this is not true; on the contrary, the method often causes considerable and important loss. In such cases there is no inducement for dealers to enter into competition, consequently such purchases can not be made as economically by the present method as by resorting to open market purchase, and, moreover, the responsible business houses which could furnish acceptable materials frequently refuse to make bids under advertisements for small orders. They express an unwillingness to incur the trouble and the formality which the present system requires, and this office is constantly pressed for instructions as to what course to pursue when bids can not be procured. In some cases, when induced by personal solicitation to make bids, they are generally above the prices at which they sell similar materials over their counters to any customers. Again, there are many special and patented articles required which it is well known only one person has for sale and which are of such small value that no one else could undertake the expense of producing them, and the formalities of taking bids are regarded by dealers as foolishness. This and the cumbersome routine of taking bids for other small articles brings the purchasing officers into contempt and has the effect of taking the business from the best dealers and relegating it to special dealers who take advantage of the state of affairs to charge excessive prices, and in this and in other ways cause the Government to suffer unnecessary and very considerable loss.

Often a greater source of loss is the fact that the cumbersome and ineffectual method involves so much trouble that officers avoid using it, and the Government thereby incurs the loss of getting along without articles which economy would otherwise demand; or, if the method is put in force, the delays it causes to work in hand are also expensive. The present construction of this law—that it applies to all purchases, both great and small—did not obtain until about seven years ago, and I beg to refer you to Appendix 9 of this report, which gives the experience of our purchasing officers under the present system, and shows that the public interests would be best subserved by allowing the supplies of small value to be procured in open market.

In order to protect the interests of the United States, I urgently recommend that Congress be asked to authorize the Department to purchase in open market, in the manner common among business men, such small supplies when the aggregate purchases at any one time do not exceed the sum of $200. When any advantage to the United States could result from advertising for these articles of small value it would always be done.

To meet such cases, and to place the United States on as favorable a footing as the individual purchaser of like small supplies, I would recommend that section 3709, Revised Statutes, be amended by inserting after the word "services," on the first line, the words "in excess of two hundred dollars;" so that the section shall then read:

> SEC. 3709. All purchases and contracts for supplies or services *in excess of two hundred dollars* in any of the Departments of the Government, except for personal services, shall be made by advertising a sufficient time previously for proposals respecting the same, when the public exigencies do not require the immediate delivery of the articles or performance of the service. When immediate delivery or performance is required by the public exigency, the articles or service required may be procured by open purchase or contract at the places and in the manner in which such articles are usually bought and sold, or such services engaged between individuals.

Existing law authorizes the Interior Department to make purchases in open market to the amount of $500.

## CLERICAL FORCE.

The clerical force is inadequate for the prompt performance of the work of this office. Five additional clerks are necessary. Four of these five additional clerks asked for are in lieu of the four who have been on duty in this office since 1886 detailed from the Surgeon-General's Office but were withdrawn from this office when the Record and Pension Division of the War Department was organized. Authority was granted to estimate for a sufficient clerical force to supply the needs of the Ordnance Office, and meet the largely increased work due to the large appropriations for gun construction and to the labor required under the act of February 12, 1887, for arming and equipping the militia.

The withdrawal of these four clerks has caused much important work to fall behind, to the inconvenience and detriment of the public service, and not infrequently to the hardship of individuals.

## DISTRICT OF COLUMBIA MILITIA.

The act of March 1, 1889 (vol. 25, p. 77, 2 Stat. at L.), to provide for the organization of the militia of the District of Columbia provides (sec. 31) that the ordnance and ordnance stores necessary to arm, equip, and instruct said militia shall be issued from the stores and supplies provided for the use of the regular Army, but the act failed to make any appropriation to enable the Ordnance Department to make good the depletion of the limited Army supplies by these issues to the militia.

As the property issued as provided for in this act must be taken from the supplies for the army, that is, from the appropriations for these supplies, and as it is a fact that the appropriations now made are insufficient for the actual needs of the Army, it is evident that if the militia is supplied the Army will suffer and *vice versa.*

The issues thus far made under this act amount to $43,793.21, and an item of this amount is embraced in the estimates to be laid before Congress. In my judgment it would be wise to have a permanent appropriation of a fixed amount for each year to provide for these issues to the District militia, or a specific appropriation for each year.

The manufactures of the Department to the extent of the limited appropriations available therefor have been carried on satisfactorily at the arsenals during the year. Some of the principal improvements of buildings, plant, etc., at the various arsenals during the year are as follows:

### THE ARMY GUN FACTORY AT THE WATERVLIET ARSENAL.

The north wing and central section of the gun factory have been completed during the year, and the steam-power plant, cranes, belting, heating apparatus, and electric-light plant put in and completed. Enough of the machines for gun work has been installed to commence work. Only one of the large lathes, a boring lathe, has been received from the manufacturers, and is in successful operation. The shrinkage pit and provision for its drainage should be completed in December, 1891.

At its last session (on February 24, 1891) Congress made an appropriation for the erection of the south wing of the factory, and this building is already far advanced and will probably be roofed in in November, 1891. This building is 400 by 155 feet. It has been made 20 feet wider than the north wing to provide space for the manufacture of 16-inch guns. On August 18, 1890, Congress made an appropriation of $320,000, and again on February 24, 1891, another appropriation of $268,000 for machinery, tools, power plant, etc., for the equipment of this wing of the gun factory. Contracts have already been made for the purchase of these machines. When the equipment of both wings of the factory is completed the estimated capacity of the gun factory will be sufficient to turn out twelve 8-inch, fifteen 10-inch, fifteen 12-inch, and three 16-inch guns per annum, besides performing certain other necessary work.

## THE SEACOAST GUN CARRIAGE FACTORY AT THE WATERTOWN ARSENAL, MASSACHUSETTS.

The labor involved and difficulties to be surmounted in supplying our fortifications with new model disappearing carriages for large guns is perhaps greater than that of supplying the guns themselves, and unfortunately this work is some years behind the guns. These difficulties are shown by the fact that foreign nations which have been expending large sums of money on this work for about twenty years have not yet arrived at a satisfactory disappearing carriage. The measures taken in the past year to supply this want are stated further on in this report.

The Department is in great need of a well-equipped seacoast carriage factory for this work. During the past year considerable additions have been made to the machines for the carriage factory at the Watertown Arsenal; an excellent foundry possessing ample facilities has been fitted up in the old east timber shed, and improvements have been made in the shop fixtures and power plant.

I would especially urge upon you the necessity for the appropriation asked for from the next Congress for further enlarging the facilities for the manufacture of carriages at the Watertown Arsenal.

## SANDY HOOK PROVING GROUND.

The anticipated completion of mortars under contract and guns at the Army gun factory during the ensuing year, the trial of new types of carriages and of armor-piercing projectiles make it necessary to considerably increase the facilities for handling heavy ordnance at the proving ground. The roads, which owing to the yielding nature of the soil have to be covered with planks, must be almost entirely renewed, and the outer or deep-water end of the dock must be strengthened to bear weights greater than those for which it was originally built. The extensive additional use of the dock due to the erection of the fortifications now in progress at Sandy Hook increases the wear of the flooring, and makes its repair a much more costly item than heretofore. With the facilities already afforded and those asked for this year it is expected that the work of testing type guns and carriages and proving the service guns can be carried on as rapidly as necessary.

## SPRINGFIELD ARMORY.

The erection of the new machine and finishing shops at the Springfield Armory, and for which the Fifty-first Congress appropriated the sum of $211,639.54, is progressing satisfactorily.

## COLUMBIA ARSENAL, TENNESSEE.

Work on the construction of this arsenal has progressed satisfactorily throughout the year. The shops, magazines, office, soldiers' barracks, barracks for married soldiers, and stables are completed, and the one set of officers' quarters and the storehouse will be completed this fall (1891). This completes all of the buildings immediately contemplated, but a considerable amount of work is yet required in the construction of roads, draining of grounds, construction of walls and fences, etc.

## ROCK ISLAND ARSENAL.

In consequence of the lack of appropriation very little has been done at this arsenal during the year on the few buildings which yet remain to be completed.

The construction of a new arsenal water-power dam wall is still in progress and should be about completed this fall (1891). Work was commenced in July on the channel for the further improvement of the water-power pool and is still in progress. The extreme low water in the river this season has made it a very favorable one for this work, and it is hoped that the work will be completed before bad weather this fall (1891).

## ROCK ISLAND BRIDGE.

The upper or railroad deck of the bridge and the two elevated shore spans have been strengthened and renewed by substituting iron beams and stringers for wood. The substitution of a stone pier in lieu of the old wooden structure, to connect the rest or protection piers of the draw pier, has been completed.

## INCREASE OF MANUFACTURES AT ROCK ISLAND ARSENAL.

It is expected at an early date to utilize some of the excellent and extensive facilities of this arsenal for manufactures by transfering the construction of field and siege carriages, and the equipments therefor, and some other manufacturing work, to this arsenal.

## ARMAMENT OF FORTIFICATIONS, ETC.

### *Seacoast guns and mortars.*

Thus far the Department has completed two 8-inch, one 10-inch, and one 12-inch B. L steel rifled gun of high power. The first 8 inch gun, made at the West Point Foundry in 1886, has been fired 300 rounds, and, excepting the usual erosion of the bore, is in good condition. A second 8 inch gun completed at the gun factory in 1890, and the first piece of that caliber produced in this country entirely of American steel, has been fired more than 100 rounds without injury, and with entire satisfaction as respects the working of the breech mechanism. Some very interesting firings have recently been made with this gun in testing a sample of smokeless powder procured from the Rottweil-

Cologne Works, Germany. The results are significant; they show a remarkable advance on the best results thus far obtained with brown powder of American manufacture, as appears from the following extract from the firing records, viz:

| Caliber. | Kind of powder. | Weight of charge. | Weight of shot. | Velocity 165 feet from muzzle. | Pressure. | Energy. |
|---|---|---|---|---|---|---|
| | | *Pounds.* | *Pounds.* | *Foot secs.* | *Pounds.* | *Foot tons.* |
| 8-inch | Brown | 125 | 300 | 1,964 | 36,480 | 8,082 |
| 8-inch | German | 45 | 300 | 1,990 | 30,105 | 8,273 |
| | Smokeless | 50 | 300 | 2,162 | 38,174 | 9,720 |

This same powder, procured for the 8-inch gun, has also been tested in the 10-inch gun, of 32 caliber length of bore. The following results show its efficiency as compared with German brown powder:

| Kind of powder. | Weight of charge. | Weight of shot. | Velocity at | Pressure per square inch. |
|---|---|---|---|---|
| | *Pounds.* | *Pounds.* | *Foot seconds.* | *Pounds.* |
| | | | at 175 ft. | |
| German, brown | 225 | 571 | 1,783 | 31,215 |
| | 225 | 571 | 1,944 | 37,287 |
| | | | at 250 ft. | |
| German, smokeless | 65 | 571 | 1,732 | 23,870 |
| | 80 | 571 | 1,960 | 34,880 |

This smokeless powder is understood to have a nitro-cotton base, and is of the Nobel type. Its properties and mode of manufacture are described in the appendix to this report.

The subject of smokeless powders is receiving the attention of the Department and of manufacturers in this country, although up to the present time experiments have been confined to the production of a powder adapted to small arms and the smaller caliber guns, such as field and rapid-firing guns. It will soon be extended to seacoast guns. Reports received from abroad speak well of the keeping qualities of this German smokeless powder and its resistance to moisture and high temperature. A sample of smokeless powder has been procured for test in the field guns, and a sample has been ordered for test in the 10-inch B. L. guns.

The firings with the 10-inch B. L. rifle, steel, have been much delayed during the past year by the breaking of the carriage, which required that it be sent to the shops for repair, and by the failure of the powder-makers to produce a suitable sample of powder. Experiments with powders are still in progress, and it is expected a suitable sample will soon be obtained. This piece has been fired thus far about 50 rounds. The proposed charge for this gun is 250 pounds, shot 575 pounds, velocity 1,950 foot seconds, and pressure 37,000 pounds; the length of bore is 32 calibers. The Messrs. Du Pont are also engaged in working up a brown powder for the 12-inch B. L. rifle. The sample of Chilworth brown powder procured from England for trial in this gun proved unsatisfactory. It was not practicable to use a charge of more than 375 pounds without exceeding the prescribed pressure, while the velocity was at least 100 feet short of that desired. The Messrs. Du Pont have thus far produced a sample which, with a charge of 440 pounds, has given a velocity of 1,862 feet to a projectile of 1,000 pounds, with a pressure on the chamber considerably below the limit, and it is expected that they will soon produce a powder that will give the results anticipated for this gun, viz: Charge of 440 to 450 pounds, shot 1,000 pounds, velocity 1,975 to 2,000 feet, pressure 37,000 pounds. The length of bore in this gun is 34 calibers.

These 10 and 12 inch type guns will be placed under systematic trial for endurance, accuracy, rapidity of fire, etc., as soon as suitable powders are obtained. Generally speaking, the working of these large guns has proved to be very satisfactory.

The constant and rapid change and improvement in smokeless powders and high explosives demonstrate the almost imperative necessity to this Department of having a suitable laboratory and experts for conducting experiments and making improvements in these powders and explosives in order that the Department may keep pace with the advance in these regards made by other nations.

Also it seems hardly proper to impose on private manufacturers all the difficulties to be overcome and labor required to perfect and produce samples of each variety of powder required for each new type of gun, and the expensive delays which have occurred in obtaining these powders indicate the necessity for having the facilities for such a laboratory include also the means of making the necessary investigations for arriving at formula for these samples and a small powder factory for manufacturing them.

The cost of these guns manufactured at the United States Gun Factory at the Watervliet Arsenal, West Troy, N. Y., under the latest contracts for forgings, is as follows, viz:

| | |
|---|---|
| 8-inch | $15,646 |
| 10-inch | 30,592 |
| 12-inch | 47,227 |

A type 12-inch B. L. mortar, entirely of steel, has been completed during the past year at the gun factory and is now at the proving ground awaiting test. These steel mortars will have considerably more power and endurance than the cast-iron mortars, with a greater margin of safety against accident. To offset these advantages, however, their cost will be nearly double that of the cast iron steel-hooped mortars. The Department is procuring mortars of this latter class from two private manufacturers under contract. The Builders' Iron Foundry, Providence, R. I., has a contract for thirty mortars, which will be completed by the end of the present year. The South Boston Iron Works has a contract for forty-three mortars, which, by the terms of its contract, should be completed by the end of 1893, making a total of seventy-three mortars completed by that date.

Under the provisions of the act approved August 18, 1890, a contract was placed with the West Point Foundry Company for finishing and assembling eleven 8 inch guns from forgings furnished by the Department. Under the provisions of the act approved February 24, 1891, which appropriated $800,000 for the purchase of forgings for 8, 10, and 12 inch guns, the Department placed a contract with the Midvale Steel Company in July last for supplying the purchase provided for, and thus securing a second source of supply for the production of heavy gun forgings. Under this contract there will be furnished twelve sets 8-inch, twelve sets 10-inch, and nine sets 12-inch forgings, which, with the deliveries to be made under the contract with the Bethlehem Iron Company, make the total number of forgings to be delivered before the end of 1896, as follows: Thirty-five sets 8 inch, thirty-five sets 10 inch, and twenty-four sets 12-inch forgings.

The manufacture, by contract, of forgings for seacoast cannon at the Bethlehem Iron Works, and for field and siege cannon and seacoast mortars at the Midvale Steel Works has progressed satisfactorily during the past year. The quality of the steel produced, as shown by the tests, has been excellent, the contract specifications having been met with no more care than should be given to this class of work.

Generally speaking, the contractors have made deliveries at the times required by their contracts.

The Midvale Steel Company will now make adequate enlargement of its plant to produce the forgings required for the seacoast guns of 8, 10, and 12 inch caliber under the contract awarded them by the Department last July.

Under the provisions of the fortifications acts approved August 18, 1890, and February 24, 1891, for supplying the Department with twenty-five 8-inch, fifty 10-inch, and twenty-five 12-inch guns, subject to all the requirements of the law, the Bethlehem Iron Company, of South Bethlehem, Pa., was the lowest bidder, and as the Board of Ordnance and Fortification adjudged the price bid to be fair to the company and to the interests of the United States, a contract for furnishing the above-stated one hundred guns has been awarded that company. The first 8-inch and 10-inch guns under this contract will be delivered by the end of 1893. The first 12-inch gun under this contract will be delivered by the end of 1894. The twenty-five 8-inch guns will be completed by the end of 1900; the fifty 10-inch and twenty-five 12-inch by the end of 1903.

The cost of these guns furnished under the Bethlehem Iron Company's contract will be about as follows, viz:

| | |
|---|---|
| 8-inch | $16,526 |
| 10-inch | 34,473 |
| 12-inch | 52,365 |

This cost is exclusive of the cost of the ten proof rounds included in the Bethlehem bid, and of any allowance for maintenance of the Army Gun Plant or interest thereon.

The 10-inch B. L. rifle, cast-iron, wire wrapped, described in Appendix 24 of the report of the Chief of Ordnance for 1886, was completed at the Watervliet Arsenal during the past year, and is now at the Sandy Hook proving ground.

This gun has a length of bore of 28 calibers and weighs about 28 tons. It is rifled with 50 lands and grooves each, with a twist increasing from 1 turn in 120 calibers at the origin to 1 turn in 35 calibers at 10 inches from the muzzle, from which point to the muzzle it continues at the same rate.

Some preliminary firings have been made—about thirty rounds in all—in testing samples of powder, to determine the charge best suited for the gun. The following are some of the results obtained:

| Kind of powder. | Weight of charge. | Weight of shot. | Velocity at 165 feet from muzzle. | Pressure |
|---|---|---|---|---|
| | *Pounds.* | *Pounds.* | | |
| German Brown, for 10-inch B. L. rifle, cast iron, wire wrapped. | 110 | 450 | 1,565 | 30,055 |
| | 115 | 450 | 1,690 | 34,455 |
| German Brown, for 10-inch B. L. rifle, steel | 154.4 | 450 | 1,738 | 27,594 |
| | 170 | 450 | 1,842 | 31,572 |
| Du Pont Brown, N. V | 130 | 450 | 1,712 | 32,350 |
| | 140 | 450 | 1,758 | 30,790 |
| | 150 | 450 | 1,812 | 35,450 |

A contract has been made with the Messrs. Du Pont for furnishing powder for the test of this gun, which shall give, with a charge of 160 pounds and projectile of 450 pounds, a velocity of 1,800 foot seconds, with a pressure of 30,000 pounds. The tests will be proceeded with as rapidly as more important work will permit.

The 12-inch B. L. rifle, cast iron, tubed with steel, is a duplicate of the 12-inch B. L. rifle, cast iron, except that it is lined over about one-half its length with an oil-tempered and annealed steel tube of from 3¼ to 4 inches thickness.

The piece has been fired thus far two hundred and twenty-eight rounds, with about the same pressures as were obtained with the 12-inch cast-iron rifle. Owing to the superior resisting power of the steel tube the bore has been far less eroded by the powder gases than the simple cast-iron gun. The piece is still in the hands of the Board for testing rifle cannon, but trials will be completed at an early day and a report rendered.

### *Seacoast carriages.*

The Department has placed a contract with the Builders' Iron Foundry, at Providence, R. I., for the manufacture of eight spring-return carriages, of the Raskazoff type, for the 12-inch mortar, with the privilege of increasing the number to the extent of the appropriation available, if desired. This will enable the Department to procure about thirty of these carriages, or a sufficient number for the mortars under manufacture at the Builders' Iron Foundry. The first carriage will be completed by the end of the present year, and the remaining seven about ten months later. This carriage is made mostly of cast iron.

Another type of carriage—the Canet type—of steel, and made principally at the works of Sir Joseph Whitworth & Co., Manchester, England, is now at the Sandy Hook proving ground, and will be tested during the present autumn.

There is now on hand at the proving ground awaiting test a 10-inch pneumatic disappearing carriage, furnished by the Pneumatic Gun Carriage and Power Company, of Washington, D. C. This carriage will be tested as soon as satisfactory powder is obtained for the 10-inch rifle.

The following type carriages are also under manufacture for tests, viz:

One 8-inch barbette and one 12-inch barbette carriage, under manufacture at the Watertown Arsenal, will be completed during the coming year. There is a sufficient appropriation available for reproducing a limited number of this class of carriage for both 8-inch and 10-inch calibers.

One 12-inch carriage for gun lift, under manufacture at the works of Le Creusot, France, will be completed at the end of October. This carriage is substantially a barbette carriage, but with an increased length of recoil to adapt it to the requirements of the gun lift.

A 10-inch disappearing carriage, Gordon type, under manufacture at the Morgan Engineering Works, Alliance, Ohio, should be completed by the end of this year. This carriage is made largely of cast iron, though the more important working parts, or organs, are of steel. It was designed by Lieut. Gordon, of the Ordnance Department.

One 8-inch and one 10 inch disappearing carriage, Buffington-Crozier type, are under manufacture at the Southwark Foundry and Machine Company, Philadelphia, Pa. Both carriages will be completed during the next fifteen months. This type of carriage is principally of steel. The principle involved in its construction was first presented by Col. Buffington, of the Ordnance Department. The present design embodies important changes, which are due to Capt. Crozier, of the Ordnance Department.

The difficulties attending the procurement of new experimental carriages by contract with private parties are great and numerous, and emphasize the pressing need of such an increase of the facilities of the heavy gun-carriage factory as will enable the Department to manufacture these carriages in its own shops.

The magnitude of a disappearing carriage for large caliber guns, and the mechanical difficulties to be overcome in devising and constructing it, can hardly be estimated and appreciated without seeing such a carriage operated. (A satisfactory disappearing carriage for large guns has not yet been produced by other nations.) It is hardly practicable to provide for all these difficulties in a contract made before commencing the carriage. It is of the utmost importance that the work of construction should be carried on by the officers of the Ordnance Department in the Department's own shops, in order that details and improvements may be worked up and perfected, and desirable changes made, which can be developed only as the work progresses. This can not be provided for in a contract made before the work commences. The work of construction is the very best school for designing, developing, and perfecting these carriages.

For these reasons, as well as others, the appropriation requested further on for increasing the facilities of the carriage factory at the Watertown Arsenal is urgently needed. The alteration of 15-inch carriages for use with increased charges of powder, and of 10-inch carriages for use with the 8-inch M. L. rifle, converted, has been carried on as usual during the past year at the Watertown Arsenal, under the appropriation of $50,000 made for the purpose by the act approved February 24, 1891. The design of these two types of carriage has been modified by placing the cylinders in rear and fitting them with obturating bars for equalizing the pressure in the cylinder. This modification will remove the difficulties that have sometimes been experienced in the working of these carriages in the service, particularly the springing of the piston rod and deterioration of the piston rod stuffing box, and it will be embodied in further alterations of carriages. When the work now in hand is completed there will have been altered the following carriages:

Fifty-one 15-inch carriages and one hundred and twenty-seven 10-inch carriages for 8-inch M. L. rifles, converted. The total number of guns on hand is three hundred 15-inch smoothbores and two hundred and ten 8-inch M. L. rifles, converted.

### *Seacoast projectiles.*

The acts of 1890 and 1891 for the armament of fortifications provided for the purchase of armor-piercing projectiles for seacoast guns. Under these acts the Department has placed two contracts for armor-piercing projectiles with the Midvale Steel Company, in quantities and kinds as follows: Three hundred and eighteen 8-inch shot, four hundred and twenty-two 10-inch shot, and fifty 12-inch shot. They are to be furnished complete ready for use.

These projectiles will be made by the Holtzer process, which is believed to be the best process for the manufacture of armor-piercing projectiles. The Midvale Company has for some time been carrying on preparations for manufacture, but has not, up to this date, furnished any shot. The delivery of the first lot is expected very soon. The entire number should be completed by the end of 1892. The armor-plates for the test of part of the 8 and 10 inch projectiles, of 9 inches and 11½ inches thickness, respectively, have been manufactured by the Bethlehem Iron Company, and are now awaiting tests prior to acceptance. Experiments are now in progress at the Sandy Hook proving ground for the purpose of establishing suitable 12-inch mortar shell for the penetration of armored decks. A first experiment made against a standard deck plate 4½ inches thick, and inclined to the horizon at an angle of 60°, thus making the actual thickness presented to penetration 5.2 inches, resulted in complete penetration and the shattering of nearly one-half the plate. The plate was 10 feet long by 5 feet wide, supported by four strong braces of timber equally spaced throughout its length. This plate was furnished by the Bethlehem Iron Company, and showed the following qualities on specimens 3 inches long, viz:

| Elastic limit. | Tensile strength. | Elongation after rupture. | Reduction of area after rupture. |
|---|---|---|---|
| *Pounds.* | *Pounds.* | *Per cent.* | *Per cent.* |
| 48,800 | 88,400 | 21.16 | 46 |
| 49,200 | 84,400 | 23.00 | 52.97 |

The steel shell was also furnished by the Bethlehem Iron Company, and was one of a lot showing a tenacity of 142,000 pounds at the base and 148,000 at the point. The velocity at impact was intended to be just sufficient for penetration of the plate, say 833 foot seconds, but it proved to be in reality about 885 foot seconds, and projectile ranged to a considerable distance beyond after passing through the plate. The oblique direction of the blow upon the head of the projectile bent the point upwards and spawled off a considerable portion of the head. Further trials will be made with projectiles having harder points and possibly some change in form. In this connection it may be observed that *three inches* is an exceptional thickness for the horizontal deck armor of most existing battle ships and cruisers.

The Department has under test what promises to be a very satisfactory form of a base fuse that will admit of delayed action when firing against armored deck plates. This fuse will be of particular value for use with mortar shell.

### *Siege service.*

*Five-inch B. L. rifle and 7-inch B. L. howitzer.*—The type guns of these two classes of cannon have passed satisfactorily the legal tests, and the manufacture of ten more pieces of each kind has been taken in hand under available appropriations; all should be completed during the coming year.

A carriage for the 5-inch gun has been produced and subjected to a test. A sufficient number of carriages will now be made at the Watertown Arsenal, Boston, Mass., for issue with the guns, an appropriation being available for the purpose.

An experimental carriage for the 7-inch howitzer has been manufactured at the Watertown Arsenal and sent to the proving ground for test. There is also available an appropriation for the further manufacture of howitzer carriages should the experimental one prove satisfactory. Cast-iron projectiles for issue with these siege pieces are under manufacture at the Watervliet Arsenal.

### *Field material.*

3.2-*inch steel field guns.*—The Department has completed one hundred of these guns and has twenty-five more under manufacture at the gun factory. Some simplification of the construction has been made in this last lot. The new model—model 1890—has the jacket and trunnions in one piece, with a locking shoulder on the extension in front of the trunnions. The breech sleeve is omitted, the breechblock being seated in the jacket.

*The* 3.6-*inch heavy field steel guns.*—The test of the type gun of this character has been completed and is satisfactory. There is an appropriation available for the further manufacture of about twenty-four of these guns, and they will be taken in hand without delay. It has been thought necessary to provide a vent-closing device for the field gun to prevent premature discharge of the piece before the breechblock is closed. Owing to the position of the vent, *i. e.*, on top of the gun, the problem was one of unusual difficulty, but it has been satisfactorily solved, and vent covers are now being manufactured at the gun factory for issue with the new guns and for attachment to those already in service. Cast-iron shell for field service are manufactured at the Watervliet Arsenal.

3.6-*inch field mortars.*—The type mortar of this class was tested last year, and the Department has now under manufacture at the gun factory sixteen more of these pieces.

*Field projectiles.*—A satisfactory shrapnel for the field service, with a base charge, has been designed and tested, and a contract for a supply has been placed with the Thomson Electric Manufacturing Company, of Lynn, Mass. Another somewhat different type of shrapnel, with the charge in the point, is now under test with promising results, and it is probable that a contract for a further supply will soon be made. After much experimenting the Department has successfully produced a reliable combination time and percussion fuse for use with field shrapnel and shell. A mechanical distance fuse is also under trial by the Department. The following changes have been made in the standard shell for the 3.2-inch gun. The weight has been increased from 13 to 13½ pounds; the position of the band has been changed from 1¼ inches from the base to five-eighths of an inch from the base. The latter change was made in order that the shell and shrapnel might have the same seating. The new position of the band facilitates considerably the construction of shrapnel. Firings made with the band in its new position have shown that there is no falling off in accuracy; if anything, there is an improvement.

*Three-inch B. L. mountain gun.*—The Department has procured a gun of this caliber from the Hotchkiss Ordnance Company for test. Some preliminary trials have already been made with full charges. Some modifications, however, will have to be made in the present ammunition, to adapt it to firing with the reduced charges which will be used with high-angle fire. When the necessary arrangements have been made, the trial of the piece will be proceeded with.

*Field carriages.*—The metal gun carriages proper, for the 3.2-inch field guns, are manufactured at the Springfield Armory. The caissons, limbers, combined battery wagons and forges are manufactured at the Watervliet Arsenal. The heavy carriage made for the 3.2-inch field gun, can, with slight modification, be adapted to the service of the 3.6-inch gun, and those issued to the service will be ultimately recalled for this purpose and be replaced by the lighter model for the 3.2-inch gun. The carriages for the 3.6-inch field mortar are all cast steel and are under manufacture at the gun factory, the castings being furnished by the Midvale Steel Company.

## POWDERS AND PROJECTILES FOR THE FIELD SERVICE.

*Powders.*—The Department has procured a type of sphero-hexagonal powder that gives satisfactory results with all the field pieces, *i. e.*, the 3.2-inch and 3.6-inch guns, and the 3.6-inch mortars. This is of great advantage, as it is considered a matter of the first importance to have a single powder for the field service. The charge for the 3.2-inch guns with the new type of powder will be 3½ pounds and for the 3.6-inch guns about 4½ pounds. A sample of French smokeless powder has been procured from abroad for trial in the field guns and is now undergoing test at the proving ground. The results indicate that with the smokeless powder of this type the charge may be reduced at least one-half. Samples of smokeless powder produced by inventors in this country are being prepared for test in the field and larger calibers of guns.

## ARMY GUN FACTORY.

The north wing of the Army Gun Factory has been in operation since last year. All the smaller machinery, such as hoop lathes, boring and turning mills, planers, slotters, shapers, drills, etc., including several [illegible] mechanism, have been [illegible] power plant, overhead [illegible] apparatus. The deli [illegible] Pond Machine [illegible] The first lathe has [illegible] new design and [illegible] dimensions [illegible]. The second lathe w [illegible] remaining lathes will [illegible] minor defects observed in the [illegible] delivered. The [illegible] number of gun lathes [illegible] for the north wing are [illegible] and [illegible] lathes. There are [illegible] These large tools [illegible] of guns from [illegible] inches caliber. [illegible] boring and turning [illegible] Arsenal are being [illegible] guns. The shrinkage pit with its [illegible] hoops and jackets heated in the [illegible] tubes and jackets [illegible] The Department has now under [illegible] and 12-inch caliber, besides [illegible] guns.

An appropriation of $[illegible] was made by the act of August [illegible] 1890, for the purchase of gun lathes, a rifling machine, and an [illegible] traveling crane for the equipment of the proposed south wing of th Army gun factory. A contract for the lathes and rifling machine wa awarded to the Pond Machine Tool Company; that for the travelin crane to the Morgan Engineering Company, Alliance, Ohio. This cran will be similar to the one furnished by this company to the Navy Department, and will readily admit of being rigged for a capacity of 11 tons.

A further appropriation of $268,000 for machinery to equip the sout wing was made by the act of February 24, 1891, and also an appropriation of $248,743 for the erection of the south wing, including ways fo traveling cranes, by the same act. The contracts for the erection of th building and for the purchase of machinery therefor were made a early as practicable after the passage of the act. The walls of the ne wing are well advanced, and the building should be under roof befor the cold weather sets in. It is expected that it will be completed an ready for the reception of the machinery by next spring, by which tim the smaller machines and the large traveling crane will be delivered and can be immediately set up in place. Work on the smaller forgings such as hoops and breech mechanism, can then be commenced in thi wing before the delivery of the large lathes. Two additional boring an turning lathes of the same general type as the others were include among the machines to be purchased from the appropriation of $268,000

The contract therefor was awarded to Niles Tool Works, Hamilton, Ohio. These two lathes are due next year.

The equipment for this wing provides for six turning and boring lathes, and six turning lathes suitable to the manufacture of guns from 8 to 12 inches inclusive, but the last one will not be completed until about June, 1895. As it is the intention to manufacture guns of not less than 12 inches caliber in the south wing, the lathes were increased in length about 6 feet in order to accommodate 12-inch guns of forty calibers total length; the north wing will ultimately be devoted mainly to the manufacture of 8 and 10 inch guns. After the machinery thus far appropriated for has been procured there will still remain space in the south wing for four more large lathes and a number of smaller tools. It is proposed to complete the equipment of this wing with machinery suited to the manufacture of 16-inch guns. The width of this wing is 20 feet greater than that of the north wing, and was made designedly so for this very purpose.

The full output of the gun factory when completed as now contemplated will be as follows, viz: Twelve 8-inch guns, fifteen 10-inch guns, fifteen 12-inch guns, and three 16-inch guns per annum.

Should an appropriation for this additional machinery be made at the next session of Congress it will hardly be practicable to procure the large lathes before the end of 1895.

## PNEUMATIC DYNAMITE GUNS.

No progress has been made by the Pneumatic Dynamite Gun Company during the past year in the manufacture of the pneumatic dynamite guns under the contracts made by this Department with that company March 8, 1889, and June 10, 1889. It is understood that this lack of progress is due to financial embarrassments of the company. The contracts required that the guns, carriages, air compressors, and other appurtenances for the successful operation of the guns should be completed, set up, successfully operated, and that the guns should be fired and give specified successful results on or before the following dates, viz:

For the Atlantic coast, on or before October 6, 1889.

For the Pacific coast, on or before June 10, 1891.

At the request of the company extensions of their contract have been granted as follows:

First extension to May 6, 1890.
Second extension to July 1, 1890.
Third extension to November 1, 1890.
Fourth extension to July 1, 1891.

### CONTRACT OF JUNE 10, 1889.

First extension to January 10, 1891.
Second extension to November 2, 1891.

After a careful consideration of the case, with the approval of the Secretary of War, another extension of the contract of March 8, 1889, was made on July 17, 1891, in order to facilitate as far as possible the completion of the guns. Under this extension the delivery of the first group, that for Sandy Hook, is now extended to January 1, 1892, and of the last group to July 1, 1892, provided the first group is delivered before January 1, 1892. The total number of ten guns under the two contracts consist of one 8-inch and nine 15-inch guns, of which three of the latter caliber are by law to be mounted on the Pacific coast. The reports furnished the Department by the Pneumatic Dynamite Gun Company of trials made of a 15-inch pneumatic dynamite gun, manufactured by them in this country for the English Government, are quite favorable to the performance of the gun and its projectiles.

## SANDY HOOK PROVING GROUND.

Under the provisions of the act approved February 24, 1891, proposals were issued under date of June 8, 1891, for supplying the Department with a Gantry crane of 80 tons capacity, and mounted on a traveling platform, both crane and platform to be operated by hand power, for use in mounting and dismounting guns at the Sandy Hook proving ground. A satisfactory bid was received from Maxwell, Manning & Moore, and a contract for the crane will be awarded them.

Some improvements have been made during the past year in the arrangement of the proof battery and the firing facilities at the proving ground, and a railway track has been laid connecting the wharf with the battery and the latter with the proof butts, which will ultimately be extended down the beach to the targets. Several new platforms in concrete have been laid, which will be fitted with heavy cast-iron bed plates, somewhat similar in principle to the face plate of a lathe, in order to admit the mounting thereon of a considerable variety of gun carriages.

The free recoil carriage described in the last annual report has been used in experiments made with the 7-inch B. L. howitzer and the 8-inch B. L. rifle in connection with the Sébert velocimeter, and has worked satisfactorily. It is expected that the results obtained in these firings, which will be extended to guns of other type and caliber, will be of the highest usefulness, as they will furnish data for determining the pressures along the bores of guns with different kinds of powders, smokeless as well as brown, and permit the solution of many other important ballistic questions relative to pressures and velocities.

## ESTIMATES FOR ARMAMENT OF FORTIFICATIONS FOR THE FISCAL YEAR ENDING 1893.

Among the principal estimates submitted by the Department for an action of Congress at its next session are the following:

| | |
|---|---|
| To complete the equipment of the south wing of the Army Gun Factory ... | $326,000 |

This will procure the necessary machines, tools, and fixtures for the manufacture of three 16-inch guns per annum, besides the lathes and other tools, such as hoop lathes, slotting machines, shapers, etc., and an additional overhead crane of 60 tons capacity will be required; also a 30-ton overhead traveling crane for use with the jacket lathes. The estimated cost of the equipment is $346,600, which can be reduced to $326,000 by reappropriating for the purpose $20,600 that will remain unused from the sum of $248,743 appropriated by the act of February 24, 1891, for the erection of the south wing; and this will be recommended to Congress.

| | |
|---|---|
| For oil-tempered and annealed steel for 8, 10, and 12 inch guns, including the parts required for the manufacture of a type 16-inch gun .......... | $1,122,000 |

In order to prevent a deficiency in the supply of forgings at the Army Gun Factory, it is imperative that a further appropriation be made at the next session of Congress for at least twelve sets 8-inch, fourteen sets 10-inch, and twelve sets 12-inch forgings. The first set of 8 inch forgings could then be delivered by the beginning of 1893, and all the remaining sets by the end of 1893; the first set of 10-inch forgings by September 1, 1893, and all the remaining sets by the end of 1894; the first set of 12 inch forgings by the end of 1893 and all the remaining sets by the end of 1894, provided contracts are made with at least two steel-makers. Any slower delivery than this would cause a deficiency.

The great length of time required to produce and test a gun of 16-inch caliber makes an appropriation therefor without further delay a pressing need. If an appropriation should be made available by June 30, 1892, the type 16-inch gun could hardly be made and tested before June 30, 1895, while the first three 16-inch guns for service would not be completed before the end of 1898. Recent improvements in the resisting power of ships' armor would seem to still further emphasize the already recognized necessity for guns of this caliber. As it would be foolish to conclude that the improvements in the resisting power of armor have reached their final limit, and as much time is required for completing a type gun of such high power as may have become an absolute necessity for overcoming such resistance, the sooner the work is commenced the better. Having provided the type gun if further constructions of so large a caliber are not immediately demanded we would at least be ready to go on with their construction when they *are* demanded. Guns of 15¾ to 17¾ inch caliber are now included in the armaments of the principal foreign powers, and have been in use since 1882. In connection with this estimate an item of $10,600 is asked for to alter one of the large lathes at the gun factory to adapt it to the manufacture of a type 16-inch gun.

| | |
|---|---|
| For steel breech-loading rifled seacoast mortars of 12-inch caliber .......... | $725,000 |

Seventy-three mortars, now under manufacture by contract at the Builders' Iron Foundry and at the South Boston Iron Works, will be completed by the end of 1893, and, unless a fresh appropriation is made next year for continuing this work, the production of mortars of this caliber for coast defense must be discontinued. The action of the Senate, at the last session of Congress, in substituting *steel* mortars for cast iron, hooped with steel, in the amendment providing for a further supply of the latter, indicates that Congress favors *all-steel* mortars.

For carriages for breech-loading rifled mortars of 12-inch caliber............ $449,500

By the acts of March 2, 1889, and August 18, 1890, the sum of $325,000 was appropriated for mortar carriages, and, as already stated, this sum will suffice for the purchase of about 30 spring return carriages, of the Raskazoff type. The sum now estimated for should provide 43 more of these carriages, which will complete the amounts required for the 73 mortars under contract.

For carriages for mounting new steel breech-loading 8-inch, 10-inch, and 12-inch guns........................................................ $1,805,000

The above sum is estimated to provide mounts for the number of 8, 10, and 12 inch guns that will be completed at the end of 1893, viz: Thirty-three 8-inch, nineteen 10-inch, and fifteen 12-inch guns.

For the thirty-three 8-inch guns to be completed, it is not probable that more than eight will be mounted on barbette carriages. Sufficient money has already been appropriated for 4 barbette carriages, leaving to be provided for, 4 barbette carriages and 25 disappearing carriages. For the nineteen 10-inch guns there will be provided 5 barbette carriages and 14 disappearing carriages. For the fifteen 12-inch guns there will be provided two barbette carriages and twelve gun-lift carriages, there being a sufficient appropriation on hand for one additional barbette carriage. The estimate also covers one type casemate carriage for a 12-inch gun, a very advantageous offer having been tendered the Department for such carriage, with the right to continue the manufacture.

For the enlargement and improvement of the heavy gun-carriage plant at Watertown Arsenal, Watertown, Mass.................................. $151,000

The object of this estimate is to provide more adequate facilities for the manufacture of the carriages, that will now be required in considerable numbers, for the new steel guns for coast defense. The work of designing and producing the carriages required is not less difficult or less in magnitude than that of producing the guns, and, unfortunately, this work is some years behind that of gun manufacture. The Watertown Arsenal is well located and well adapted for this class of work, and no very great expense is anticipated in increasing its facilities to the extent desired.

The Department has also submitted the following usual estimates of $200,000 for armor-piercing steel projectiles, and a sufficient sum for procuring the plates for testing the same; $100,000 for deck-piercing shell for 12-inch B. L. mortars, also an item for plates for testing the same; $100,000 for the alteration of 15-inch carriages, and 10-inch carriages for use with 8-inch M. L. rifle for Watertown Arsenal; for an additional lot of twenty-five 3.2-inch guns and their carriages; for twenty-five 5-inch siege guns; for twelve 7-inch howitzers and their carriages, and for powders and projectiles for issues to the service for field, siege, and seacoast guns, and for proving the new seacoast guns and mortars as they are completed.

### MAGAZINE SMALL ARM.

The question of procuring for the Army a magazine rifle (small arm) of reduced caliber has engaged the attention of the Department for some time, and while no direct steps were taken until last fall, yet for some time experiments had been in progress at the Springfield Armory to determine the most appropriate caliber and the best form and weight of projectile. Connected with these trials were many tests of smokeless powders, resulting finally in the selection of one sufficiently satisfactory for use in the examination and test of small arms.

A quantity of this powder has been procured from the Wetteren factory, Belgium, and the reduced caliber of 0.30 inch decided upon for exhaustive trial. After many experiments a satisfactory cartridge has been arrived at and 100,000 of them manufactured at the Frankford Arsenal, for the trial of the new caliber arms.

A board of officers, four from the infantry and cavalry, with two from the Ordnance Department, was assembled last December to consider and recommend a suitable magazine system for rifles and carbines.

Advantage was early taken of the experience of similar commissions abroad, and through the courtesy of our State Department and of foreign governments the magazine small arms selected for the principal European armies have been procured and subjected to trial by the board. These include the Lee-Speed, Mark I, of England; the Mannlicher, of Austria; the Krag-Jorgensen, of Denmark; the Mauser, of Belgium; the "Infantry Rifle," of Germany; the Kropatschek, of Portugal, and the Murata, of Japan. The Schmidt, of Switzerland, is on hand, awaiting the arrival of suitable ammunition for its test. Several other foreign guns are also expected and will be tested when received. The knowledge gained by the trial of these arms, which are the best other nations have been able to produce, is valuable.

The radical change from a caliber of .45 inch (our present service standard) to the much smaller one of .30, the use of the long and narrow cartridge thereby necessitated, and the introduction of smokeless powders for imparting a greatly increased velocity to the bullet without subjecting the barrel and breech system to undue augmented strain, have all operated to retard the efforts of American inventors to perfect their guns, and the result is that but few magazine arms of American design have yet been brought before the board. To assist inventors the Department has sold, at cost price, caliber .30 barrels and smokeless powder cartridges for such preliminary experiments as they might desire to make. A number have availed themselves of these opportunities and will probably soon have their inventions ready for trial by the board.

The elaboration of a magazine system suitable for the military service is an operation requiring not only ingenuity, but both time and patience to bring it to perfection. Experience has demonstrated the ability of American inventors to produce the best small arms in the world adapted to the conditions which formerly existed. This Department is doing all in its power to afford American inventors all opportunity to meet the requirements of new existing conditions.

Reports of foreign service indicate that continuous rapid firing may not be expected in the use of the magazine rifle, as it is limited by the endurance of the soldier and the heating of the gun. The following extract from General Information Series, No. X, published by the office of Naval Intelligence, is of interest in this connection.

> Interesting experiments carried out in France give a good idea of the rapidity of fire possible with magazine arms. Ten soldiers were selected to fire with maximum rapidity at a target 984 feet distant, representing 15 men standing a few inches apart.
>
> These soldiers selected a kneeling position for firing, and each had a companion standing near him to supply him with another rifle as soon as the one he was using heated to such a degree as to be unfit for use. The hits averaged only 8.6 per cent. The rifles all heated between the twentieth and twenty-fifth shots, and new ones were immediately handed to the men. The soldiers were compelled, from physical exhaustion alone, to cease firing at the end of a time averaging ten minutes for the entire party, during which the average of shots per man for the entire party was 154.2.

Reports from our Army show that an expert soldier can fire the present service Springfield single-loader with the accuracy generally needed in action, about twenty times per minute. So far as rapidity of fire alone is concerned these reports reduce somewhat the almost universally estimated necessity for an immediate change to a magazine system.

It is important to state that up to the present time the investigations made and knowledge gained by this Department have not demonstrated so much excellence in the magazine arms which have been adopted by foreign nations as was expected, and have not shown such perfection in any one of them as could warrant its adoption for our service. It is hoped that this country can produce a better arm, and until it can, or certainly until it has been demonstrated that it can not, it would be wise to defer a change from the excellent single-loader now in service to a magazine system. No efforts will be spared to arrive at a satisfactory magazine arm.

## CALIBER .30 RIFLE AND AMMUNITION.

The advantages of a reduction of caliber and of a change to smokeless powder for the cartridge are well established, though in regard to the latter much has yet to be determined in regard to the ability of this country to supply a suitable powder in suitable quantities, and of the ability of such powders to stand long storage and exposure to low temperatures without too great deterioration of their ballistic qualities.

The success that has been arrived at in the manufacture of the caliber .30 cartridge at the Frankford Arsenal and the excellent results obtained with the new caliber .30 Springfield single-loader lead the Department to believe that if the adoption of a magazine arm is deferred the Department may at an early date commence to furnish to the Army reduced caliber arms and ammunition charged with a satisfactory smokeless powder. The Department is earnestly urging on the experiments and other work for arriving at a solution of this question, and as soon as a satisfactory powder can be obtained the question of the immediate adoption of the reduced caliber arm will be submitted to a board. (Attention is invited to Appendix 16 on the manufacture of the reduced caliber ammunition.)

In the proposed improvements in small arms and small-arm ammunition probably nothing may be anticipated to cause more delay and require more urgent effort to overcome than the difficulty of procuring in this country sufficient quantities of suitable smokeless powders. The Department is doing all in its power to induce and aid inventors and manufacturers to perfect these powders.

In connection with this subject attention is invited to what has already been stated in this report in regard to the establishment of a suitable laboratory for this and other purposes at the Frankford Arsenal.

## REVOLVERS.

A number of each of the new double-action revolvers, caliber .38, with simultaneous ejector, and Smith & Wesson safety hammerless revolvers of the same caliber, with 6-inch barrel, were purchased and issued for trial by troops in service during the past year. A report upon an antecedent trial of these revolvers, made by a board convened at the Springfield Armory, Massachusetts, is published in the Annual Report of the Chief of Ordnance, 1889, Appendix 12. The board concluded that a competitive test in service would be necessary to determine the relative merit of the weapons. One hundred of each of the revolvers were accordingly procured and have been on trial with nine troops of the First, Third, Fifth, Sixth, Eighth, and Ninth Cavalry. The reports which have been received from the troop commanders with two exceptions favor the Colt revolver and consider it a very decided improvement upon the caliber .45 Colt now in service. Steps have been taken to recall the experimental revolvers and they will be returned to the armory for examination following their use in the service. In view of the impending change in the rifle and probable adoption of smokeless powder for small-arm ammunition it is not deemed expedient to make an immediate change in the service revolver. It is deemed best to await the outcome of the present state of affairs in order to secure the best ballistic effects in the revolver as well as the rifle and have a uniform system of small arms in such requirements as are common to all three arms—the rifle, the carbine, and the revolver.

The campaign in connection with the Indian disturbance at Pine Ridge wherein the troops marched over and camped in every variety of country and were exposed to storms and to cold far below the freezing point enabled the Department to obtain valuable information regarding material in service. Capt. Ayres, of the Ordnance Department, has furnished valuable reports and much useful information in regard to experience gained in this campaign. It may be mentioned that the saber and bayonet were not carried, and this fact would seem to substantiate the views of those officers who are in favor of abandoning these weapons.

### EXPERIMENTAL MATERIAL FOR EQUIPMENT.

Reports have been received from officers of the Army in relation to the trial of materials issued experimentally.

These reports treat of the following subjects:

First. The Wint saddle.
Second. The Williams folding feed basket.
Third. A carbine scabbard or sheath to be issued in place of the boot.
Fourth. The Merriam pack.
Fifth. The intrenching knife.

All the reports are adverse to the use of the Wint saddle and the Williams folding feed basket.

All the reports are in favor of the substitution of the carbine scabbard for the carbine boot, and on the adoption by the Board on Magazine Small Arms of a new carbine the scabbard will be substituted for the boot. It is not considered judicious to make the change at present, as the form of the scabbard may to some extent depend upon the shape of the magazine in the new carbine.

The reports on the Merriam pack are inconclusive. Up to this time fifty-two reports have been received, of which twenty-three are favorable and twenty-nine unfavorable. Eight companies are still to be heard from. A number of officers adhere to the opinion that a blanket roll is the most suitable device for active service, but on the other hand a board called to consider this special subject objects to the use of the roll.

The reports on the intrenching knife issued are various. Up to the present time seventy-seven reports have been received, of which forty-three are favorable, twenty unfavorable, and fourteen are neither favorable nor unfavorable. The adoption of a separate intrenching tool is under consideration, and such tools are under trial.

A board was convened to consider the subject of a blanket roll and the Bell shelter tent. They report adversely to the use of the roll, but think that the tent is desirable and have recommended that one hundred be fabricated and issued to the service for trial.

I have also the honor to submit herewith the following papers as appendices to this report:

*Appendix* 1.—Statement of principal articles procured by fabrication during the year ended June 30, 1891.

*Appendix* 2.—Statement of principal articles procured by purchase during the year ended June 30, 1891.

*Appendix* 3.—Statement of ordnance, ordnance stores, etc., issued to the Military Establishment, including the national homes for soldiers of the volunteer and regular Army and exclusive of the militia, during the year ended June 30, 1891.

*Appendix* 4.—Statement of ordnance, ordnance stores, etc., distributed to the militia from July 1, 1890, to June 30, 1891, under section 1667, Revised Statutes.

*Appendix* 5.—Statement of ordnance, ordnance stores, etc., distributed to the colleges from July 1, 1890, to June 30, 1891, under section 1225, Revised Statutes.

*Appendix* 6.—Statement of arms and ammunition issued to the Executive Departments during the year ended June 30, 1891, under the provisions of the act of March 3, 1879.

*Appendix* 7.—Report of action taken during the year ended June 30, 1891, under the provisions of the act approved March 3, 1881.

*Appendix* 8.—Showing the stations and duties of the officers of the Ordnance Department.

*Appendix* 9.—Reports on making small purchases.

*Appendix* 10.—Reports of the principal operations at Columbia Arsenal (1 plate).

*Appendix* 11.—Report of the principal operations at Rock Island Arsenal.

*Appendix* 12.—Report of the principal operations at Watervliet Arsenal (2 plates).

## REPORTS FROM SPRINGFIELD ARMORY.

*Appendix* 13.—Trials of smokeless powders—Reports Nos. 1 to 7.

*Appendix* 14.—Trials of Clay's cartridge shell.

*Appendix* 15.—Practice firings by the Armory Rifle Club.

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*Appendix* 16.—Manufacture of caliber .30 cartridges at the Frankford Arsenal, and experiments attending the same.

## CONSTRUCTION OF ORDNANCE.

*Appendix* 17.—Report on manufacture of 12-inch B. L. rifle, steel, No. 1 type, at Watervliet Arsenal (10 plates).

*Appendix* 18.—Report on manufacture of 12-inch B. L. mortar, steel, No. 1 type, at the Watervliet Arsenal (7 plates).

*Appendix* 19.—Report on manufacture of Frankford Arsenal combination fuse with channel time train (1 plate).

*Appendix* 20.—Report on manufacture, with description of Frankford Arsenal combination fuse, tubular time train (3 plates).

*Appendix* 21.—General specifications governing the manufacture and inspection of carriages and parts of carriages for cannon.

*Appendix* 22.—Instructions to bidders and special specifications governing the manufacture of spring return carriages for 12-inch B. L. mortars.

*Appendix* 23.—Instructions to bidders and specifications for the manufacture of type and service 8, 10, and 12 inch single charge, steel breech-loading guns.

*Appendix* 24.—Instructions to bidders, and special specifications governing the manufacture of 8 and 10 inch disappearing gun carriages.

*Appendix* 25.—Progress report on manufacture of steel forgings, etc., at the Midvale Steel Company, Philadelphia, Pa.

*Appendix* 26.—Progress report on manufacture of steel forgings, etc., at the Bethlehem Iron Works, South Bethlehem, Pa.

*Appendix* 27.—Revised specifications governing the manufacture of steel for cannon.

*Appendix* 28.—Report on manufacture of twenty metallic carriages for machine guns (4 plates).

## ARMY GUN FACTORY.

*Appendix* 29.—Specifications for excavations and masonry and foundations for south wing of Army Gun Factory.

*Appendix* 30.—Specifications for the delivery and erection of the iron work for the south wing of Army Gun Factory.

*Appendix* 31.—Specifications for the erection and completion of superstructure, south wing of Army Gun Factory.

*Appendix* 32.—Specifications for gun lathes required for the equipment of the south wing of Army Gun Factory.

*Appendix* 33.—Specifications for machine tools required for the equipment of the south wing of the Army Gun Factory.

## ORDNANCE PROVING GROUND.

*Appendix* 34.—Report on firings with 13½-pound 3.2-inch shell with band at 1¼ inches and five-eighths inch from base (10 plates).

*Appendix* 35.—Report on test of experimental carriage for 5-inch B. L. siege gun, steel (1 plate).

*Appendix* 36.—Report on tests of Hotchkiss 3.2-inch shrapnel (21 plates).

## REPORTS OF BOARD FOR TESTING RIFLED CANNON, ETC.

*Appendix* 37.—Report of test of 3.6-inch B. L. mortar, steel, No. 1, type (15 plates).

## REPORTS OF THE ORDNANCE BOARD.

*Appendix* 38.—Tests of Armstrong's combination time and percussion fuse (1 plate).

## MISCELLANEOUS.

*Appendix* 39.—Smokeless powders, firing results, etc. (1 plate).

*Appendix* 40.—Caisson and combined forge and battery wagon for 3.2-inch gun.

I have the honor to be, very respectfully, your obedient servant,

D. W. FLAGLER,
*Brigadier-General, Chief of Ordnance.*

The honorable SECRETARY OF WAR.

○

# APPENDIX 1.

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*Statement of principal articles procured by fabrication at the arsenals during the fiscal year ended June 30, 1891.*

## CLASS I.

1 12-inch breech-loading rifle (type), No. 1.
25 3.2-inch breech-loading rifles, steel.
1 12-inch breech-loading mortar (type), No. 1.

## CLASS II.

1 carriage for 3.6-inch breech-loading field mortar.
21 carriages, metallic, for Gatling guns, model 1890, with mounts.
1 carriage for 5-inch breech-loading siege gun.
10 15-inch barbette carriages and chassis.
22 caissons and limbers for 3.2-inch guns.
20 limbers for machine gun carriages.
2 mortar wagons.
6 combined forges and battery wagons.

## CLASS III.

28 breech sights for 3.2-inch rifles.
2 breech sights for 3.6-inch rifles.
1 front sight for 3.6-inch rifle.
1 front sight for 8-inch rifle.
1 rear sight for 3.2-inch rifle.
7 rear sights for 8-inch rifles.
1 support telescopic sight for 3.2-inch rifle.
50 breech straps for 3.2-inch rifle.
2 muzzle covers and sights.
3 pouches for sights.
2 pouches for primers.
1 pouch for pendulum hausse.
505 water buckets.
18 fuse wrenches.
6 gunners' gimlets.
13 gunners' reamers.
2 gun covers for Gatling guns.
5 canvas covers for ammunition chests.
12 handspikes, trail.
38 handspikes.
20 sets harness for two wheel horses.

| | |
|---|---|
| 15 | sets harness for two lead horses. |
| 2 | sets harness for Hotchkiss mountain gun. |
| 156 | harness sacks. |
| 2 | lanyards. |
| 12 | priming wires. |
| 13 | prolonges. |
| 1 | quoin. |
| 4 | mauls. |
| 42 | thumbstalls. |
| 2 | rammers and staves for 12-pounder guns. |
| 8 | rammers and staves for 4½-inch siege guns. |
| 2 | rammers and staves for 11-inch rifle. |
| 15 | sponges and rammers, jointed, for 3.2-inch guns. |
| 10 | sponges and rammers, combined, for 3.2-inch guns. |
| 37 | sponges and rammers for 6-pounder guns. |
| 9 | sponges and rammers for 12-pounder guns. |
| 26 | sponges and rammers for 3-inch rifles. |
| 8 | sponges and staves for 8-inch rifles. |
| 8 | sponges and staves for 10-inch rifles. |
| 9 | sponges and staves for 13-inch mortars. |
| 100 | sponge covers for 3-inch rifles. |
| 6 | sponge covers for 12-pounder guns. |
| 5 | sponge covers (bore) for 3.2-inch rifles. |
| 18 | sponge covers (chamber) for 3.2-inch rifles. |
| 75 | tompions for 3-inch rifles. |
| 2 | tompions for 8-inch rifles. |
| 2 | tompions for 6-pounder guns. |
| 23 | scrapers for cannon. |
| 4 | scrapers for carriages. |
| 95 | vent covers. |
| 7 | vent punches. |
| 29 | vent pieces. |
| 23 | wipers for mortars. |
| 1 | cleaning brush for Hotchkiss revolving gun. |
| 1 | cushion for Hotchkiss revolving gun. |
| 1 | grease box for Hotchkiss revolving gun. |
| 18 | feed guides for Gatling gun. |
| 3 | hoppers for Gatling gun. |

### CLASS IV.

| | |
|---|---|
| 185 | 8-inch cored shot. |
| 186 | 10-inch solid shot. |
| 50 | 12-inch solid shot. |
| 1,000 | 8-inch shells. |
| 200 | 12-inch mortar shells. |
| 6,173 | 3.2-inch shells, long. |
| 720 | 3.6-inch shells. |
| 1,050 | 5-inch shells, siege guns. |
| 637 | 7-inch shells, siege howitzer. |
| 20 | 3-inch Hotchkiss shot, fixed. |

### CLASS VI.

| | |
|---|---|
| 5,041 | Springfield rifles, caliber .45, model 1884. |
| 24,361 | Springfield rod-bayonet rifles, model 1888. |
| 1 | officer's sword. |

| | |
|---|---|
| 500 | sabers, officers', cavalry. |
| 150 | sabers, officers', light artillery. |
| 406 | knives for hospital corps. |

## CLASS VII.

### ARTILLERY ACCOUTERMENTS.

| | |
|---|---|
| 100 | artillery knapsacks. |
| 500 | saber belts and plates. |
| 4 | sword knots. |

### CAVALRY EQUIPMENTS.

| | |
|---|---|
| 2,750 | pistol holsters. |
| 2,150 | saber belts and plates. |
| 763 | saber knots. |
| 4,000 | saber straps. |

### INFANTRY EQUIPMENTS.

| | |
|---|---|
| 10,000 | bayonet-scabbard bodies. |
| 3,270 | bayonet scabbards. |
| 1,125 | blanket bags. |
| 1,350 | pairs blanket bag shoulder straps. |
| 7,155 | cartridge boxes, McKeever pattern, 1874. |
| 4,000 | cartridge belts. |
| 5,600 | canteens. |
| 600 | canteen straps. |
| 800 | frogs, sliding. |
| 25,400 | gun slings. |
| 1,440 | haversacks. |
| 210 | haversack straps. |
| 4,512 | forks. |
| 4,512 | knives. |
| 10,000 | tin cups. |
| 16,801 | waist belts and plates. |
| 27 | waist belts, non-commissioned officers'. |
| 16,000 | meat cans. |
| 350 | sword belts and plates, officers'. |

### APPENDAGES.

| | |
|---|---|
| 27,541 | headless shell extractors. |
| 25,620 | screw-drivers |
| 16,150 | wooden wiping rods. |
| 67 | pistol grip screws. |
| 2 | sets screws for bullet mold. |

### HORSE EQUIPMENTS.

| | |
|---|---|
| 713 | bridles, curb, cavalry. |
| 1 | carbine socket. |
| 100 | girths. |
| 3,160 | halters and straps. |
| 1,000 | horse covers. |

| | |
|---|---|
| 2,000 | lariats. |
| 1,064 | nose-bags. |
| 2,123 | saddles, cavalry. |
| 250 | saddle bags, canvas. |
| 1,050 | saddle bags, leather. |
| 10 | saddle cloths, staff officers. |
| 65 | saddle cloths, line officers. |
| 179 | saddle cloths. |
| 1 | socket for guidon. |
| 1,000 | pair spurs and straps. |
| 12 | horse equipment covers. |
| 1 | saddle cloth, dyed duck. |

## Class VIII.

| | |
|---|---|
| 22,382 | blank cartridges, 12-pounder gun. |
| 10,049 | blank cartridges, 6-pounder gun. |
| 2,884 | blank cartridges, 12-pounder howitzer. |
| 39,857 | blank cartridges, 3-inch rifle. |
| 5,825 | blank cartridges, 3.2-inch rifle. |
| 185 | blank cartridges, 15-inch gun. |
| 3,032,921 | rifle ball cartridges, caliber .45. |
| 2,009,076 | rifle and carbine blank cartridges, caliber .45. |
| 111,770 | rifle ball cartridges, caliber .30. |
| 900 | rifle ball cartridges (dummy), caliber .30. |
| 1,004,422 | carbine ball cartridges, caliber .45. |
| 501,512 | revolver ball cartridges, caliber .45. |
| 502,092 | revolver blank cartridges, caliber .45. |
| 5 | paper fuses, 5 seconds. |
| 10 | paper fuses, 10 seconds. |
| 10 | paper fuses, 20 seconds. |
| 85 | combination fuses, 3.2-inch. |
| 130 | fuses, percussion, experimental. |
| 500,000 | carbine bullets, caliber .45, 405 grains. |
| 3,001,000 | rifle bullets, caliber .45, 500 grains. |
| 3,250 | rifle bullets, caliber .30. |
| 2,350 | pounds balls, 3.2-inch shrapnel. |
| 302,300 | friction primers for cannon. |
| 4,220 | electric primers for cannon. |
| 40 | electric primers, obturator, experimental. |

## Class IX.

| | |
|---|---|
| 435 | blocks. |
| 30 | half blocks. |
| 46 | quarter blocks. |
| 1 | block, iron, single. |
| 1 | block, iron, double. |
| 1 | block, snatch. |
| 2 | capstans. |
| 185 | gun chocks. |
| 90 | roller chocks. |
| 57 | wheel chocks. |
| 2 | gun collars. |
| 1 | gun cradle. |
| 124 | long rollers. |

| | |
|---|---|
| 10 | short rollers. |
| 34 | shifting planks. |
| 18 | skids. |
| 6 | sling chains. |
| 1 | sling cart, large. |
| 2 | gun shears. |
| 86 | way planks. |
| 20 | platforms for mortars. |
| 15 | platforms for guns. |
| 30 | cap ornaments. |
| 6 | sets floor boards. |
| 2 | sets trestles for mortars. |
| 7 | gin falls. |
| 2 | gins, garrison. |
| 3 | loading cranes. |
| 13 | marking outfits. |
| 1,700 | marksman's buttons. |
| 3 | hoisting pulleys. |
| 4 | staging planks. |
| 10 | sets bench reloading tools. |
| 106 | chargers. |
| 500 | dies, resizing. |
| 181 | dies, reloading. |
| 150 | priming tools. |
| 259 | punches, reloading. |
| 50 | punches, resizing. |
| 170 | funnels. |
| 21 | drifts, No. 20 shells. |
| 2 | shell-resizing tools. |
| 683 | reloading tools, various. |
| 100 | brush wipers. |
| 14,000 | centers for paper targets. |
| 12,000,000 | pasters. |
| 548 | signal flags. |
| 250 | shot marks. |
| 574 | streamers for rifle range. |
| 30 | targets, Brinton. |
| 25 | targets, Cushing. |
| 387 | targets, revolving, Laidley. |
| 15 | targets, artillery. |
| 65,000 | targets, paper. |
| 2,562 | target frames. |
| 46,404 | silhouettes, cloth and paper. |

## Class X.

| | |
|---|---|
| 1 | crank spring for Gatling gun. |
| 1 | gas-check pad for 10-inch wire-wound rifle. |
| 2 | brass trunnion bushings. |
| 2 | trunnion rings. |
| 1 | obturator, De Bange. |
| 1 | obturator pad. |
| 6 | obturators, Freyre. |
| 2 | gas-check rings (obturators). |
| 2 | ammunition chests. |
| 1 | stock for field carriage. |

| | |
|---|---|
| 687 | cam-latch springs. |
| 1 | breech-block, complete. |
| 2 | breech screws. |
| 5,630 | front sights. |
| 4,775 | front-sight pins. |
| 693 | tang screws. |
| 30 | rod-bayonet heads. |
| 212 | bands, upper. |
| 12 | band swivels. |
| 146 | bands, lower. |
| 463 | lock plates. |
| 242 | mainsprings. |
| 317 | mainspring swivels. |
| 145 | mainspring swivel rivets. |
| 240 | hammers. |
| 1,148 | tumblers. |
| 922 | tumbler screws. |
| 389 | bridles. |
| 300 | bridle screws. |
| 1,469 | sears. |
| 633 | sear screws. |
| 389 | sear springs. |
| 248 | sear-spring screws. |
| 19 | locks, complete. |
| 261 | side screws. |
| 289 | front-sight covers. |
| 2,230 | ramrods. |
| 6 | side-screw washers |
| 11 | jointed ramrods. |
| 433 | bayonets. |
| 115 | bayonet clasps. |
| 550 | bayonet-clasp screws. |
| 12 | bayonet-clasp stop screws. |
| 4 | swivels, complete. |
| 99 | front-sight cover pins. |
| 4 | swivel-bar rings. |
| 3,804 | bayonets, complete. |
| 714 | sight-protector bands. |
| 118 | front-sight cover screws. |
| 20 | springs for carbine swivel. |
| 2,004 | sight-protector bands. |
| 1 | base spring, movable. |
| 4 | parts officers' swords. |
| 3 | parts officer's cavalry saber. |
| 2,000 | waist-belt plate catches. |
| 200 | shoulder-strap hooks. |
| 100 | snap hooks for officer's sword-belt. |
| 36 | collar pads. |
| 1,000 | guard plates. |
| 3,745 | Hoffman attachments. |
| 140 | leather thongs for cartridge belts. |
| 3,000 | hook attachments. |
| 4 | buckles, various. |
| 1,375 | bits, curbs, cavalry. |
| 2,000 | foot-staples, brass. |
| 3,000 | halter straps. |

| | |
|---:|---|
| 4 | hooks, double S. |
| 1,012 | hooks, snap. |
| 5 | breast straps. |
| 60 | steel bars for curb bits. |
| 24 | brass rings, 1¼-inch. |
| 400 | brass rings, 2½-inch. |
| 60 | saddlebag straps. |
| 424 | pairs stirrups, hooded. |
| 40 | rowels for spurs. |
| 588 | stirrups, hooded with socket for guidon. |
| 3,000 | coat straps for saddles. |
| 440 | saddle trees. |
| 1,000 | snaps, steel, double. |
| 6,559 | cartridge bags, 6-pounder. |
| 22,850 | cartridge bags, 12-pounder. |
| 24,950 | cartridge bags, 3-inch rifle. |
| 12,675 | cartridge bags, 3.2-inch rifle. |
| 940 | cartridge bags, 3.6-inch mortar. |
| 1,628 | cartridge bags, 4.5-inch rifle. |
| 150 | cartridge bags, 5-inch rifle. |
| 15 | cartridge bags, 7-inch howitzer. |
| 808 | cartridge bags, 8-inch muzzle-loading rifle. |
| 425 | cartridge bags, 8-inch breech-loading rifle. |
| 515 | cartridge bags, 10-inch gun. |
| 360 | cartridge bags, 15-inch gun. |
| 170 | cartridge bags, 12-inch breech-loading rifled mortar. |
| 1,070 | cartridge bags, 3.6-inch rifle. |
| 356 | cartridge bags, 12-inch breech-loading rifle. |
| 7,000,800 | cartridge primers. |
| 1,950 | cartridge shells, rifle, caliber, .30. |
| 20,000 | cartridge shells, revolver. |
| 4,250 | cartridge shells, rifle and carbine. |
| 851 | parts of targets. |
| 6,444 | parts of Laidley revolving targets. |
| 4 | poles, hand sling cart. |
| 18 | parts of floating targets. |
| 62,200 | cloth silhouettes. |
| 30,603 | paper silhouettes. |
| 609 | bolts and nuts for target plates. |
| 1 | wheel for sling cart. |
| 12 | plates for platform disappearing carriage. |
| 1 | pole for sling cart. |
| 120 | angle irons for targets. |
| 302 | bolts, etc., for mortar platform. |
| 3 | sets bolts, etc., for gun-lift. |
| 11 | holdfasts for capstans. |
| 307 | silver bars for sharpshooters' badges. |
| 6 | gin shoes, barbette. |

### TOOLS AND MISCELLANEOUS.

| | |
|---:|---|
| 1,542 | arm chests. |
| 3,914 | boxes, packing. |
| 61 | tin cans. |
| 1 | case for stamps. |
| 10 | crates, packing. |

| | |
|---|---|
| 152 | bronze castings. |
| 100 | boxes cleaning materials. |
| 310 | barrels, rifle, for drill cartridge, Hotchkiss. |
| 6 | coal bags. |
| 142 | aprons, smiths'. |
| 844 | brushes. |
| 133 | bits, assorted. |
| 2 | burrs. |
| 57 | chisels, various. |
| 656 | chamois skin cases for swords. |
| 53 | counterbores. |
| 770 | dies, various. |
| 1,372 | drills. |
| 3 | drifts. |
| 1,207 | files, assorted. |
| 328 | files, rotary. |
| 4 | fuse housings. |
| 4 | fixtures, rods, etc., for caliper arms. |
| 2 | gauge rings for projectiles. |
| 154 | gauges. |
| 1 | gas check. |
| [illegible] | cylinders, pressure gauge. |
| 1,000 | gas checks, pressure gauge. |
| [illegible] | gas check cups, pressure gauge. |
| 100 | gaskets, pressure gauge. |
| 2 | guides, star gauge. |
| 15 | sets measuring points, star gauge. |
| [illegible] | ring gauges for setting star gauge. |
| 1 | standard gauge, 12 inch mortar. |
| 1 | [illegible] conical roller. |
| [illegible] | [illegible] pressure |
| [illegible] | [illegible] |
| [illegible] | [illegible] for caliper arms. |
| [illegible] | [illegible] |
| [illegible] | [illegible] |
| [illegible] | [illegible] |
| [illegible] | [illegible] |
| [illegible] | [illegible] |
| [illegible] | [illegible] |
| [illegible] | [illegible] |

| | |
|---|---|
| 260 | pounds olive paint. |
| 541 | pounds paint. |
| 5 | plugs, caliber. |
| 13 | arm racks for light batteries. |
| 160 | arm racks, portable. |
| 305 | reamers. |
| 1 | set stamps, figures. |
| 1 | set stamps, letters. |
| 13 | stamps, seal. |
| 1 | stencil plate. |
| 16 | sets stencil outfits. |
| 5 | screw-drivers, hand or brace. |
| 74 | tables. |
| 161 | taps, various. |
| 25 | tool chests. |
| 110 | tools for current service. |
| 3 | tools, various. |
| 36 | tool bags. |
| 6 | templets, profile. |
| 100 | pounds black wax. |
| 4 | wrenches. |
| 50 | pounds wheel grease. |
| 1 | wooden model, 10-inch breech-loading rifle. |
| 25 | boundary posts, cast-iron. |
| 6 | grindstones, crank, etc. |
| 12 | bolts and nuts. |
| 25 | wheel-grease can knives. |
| 2 | dust pans. |

| | |
|---|---|
| 152 | bronze castings. |
| 100 | boxes cleaning materials. |
| 310 | barrels, rifle, for drill cartridge, Hotchkiss. |
| 6 | coal bags. |
| 142 | aprons, smiths'. |
| 844 | brushes. |
| 133 | bits, assorted. |
| 2 | burrs. |
| 57 | chisels, various. |
| 656 | chamois skin cases for swords. |
| 53 | counterbores. |
| 770 | dies, various. |
| 1,372 | drills. |
| 3 | drifts. |
| 1,207 | files, assorted. |
| 328 | files, rotary. |
| 4 | fuse housings. |
| 4 | fixtures, rods, etc., for caliper arms. |
| 2 | gauge rings for projectiles. |
| 154 | gauges. |
| 1 | gas-check. |
| 552 | cylinders, pressure gauge. |
| 1,000 | gas checks, pressure gauge. |
| 300 | gas-check cups, pressure gauge. |
| 100 | gaskets, pressure gauge. |
| 2 | guides, star gauge. |
| 15 | sets measuring points, star gauge. |
| 15 | ring gauges for setting star gauge. |
| 1 | chamber gauge, 12-inch mortar. |
| 1 | templet, conical roller. |
| 2 | gauges, pressure. |
| 26 | caliper arms. |
| 10 | sets measuring points for caliper arms. |
| 29 | washers. |
| 1 | gauge, star. |
| 2 | hand barrows. |
| 4 | hammers. |
| 30 | horses', saddlers. |
| 2 | handles. |
| 1 | horse cart. |
| 100 | boxes ingredients for leather blacking. |
| 7 | jigs, filing. |
| 2 | jigs, drilling. |
| 42 | gallons lacker. |
| 24 | lanterns, magazine. |
| 6 | mallets. |
| 4 | eyeletting machines. |
| 1 | bullet canneluring machine. |
| 2,187 | mills, armorers'. |
| 59 | mandrels. |
| 1 | muzzle and stencil ring. |
| 12 | oil cans. |
| 4 | oilers. |
| 1,000 | pounds harness oil. |
| 8 | punches, assorted. |
| 100 | pounds black paint. |

| | |
|---|---|
| 260 | pounds olive paint. |
| 541 | pounds paint. |
| 5 | plugs, caliber. |
| 13 | arm racks for light batteries. |
| 160 | arm racks, portable. |
| 305 | reamers. |
| 1 | set stamps, figures. |
| 1 | set stamps, letters. |
| 13 | stamps, seal. |
| 1 | stencil plate. |
| 16 | sets stencil outfits. |
| 5 | screw-drivers, hand or brace. |
| 74 | tables. |
| 161 | taps, various. |
| 25 | tool chests. |
| 110 | tools for current service. |
| 3 | tools, various. |
| 36 | tool bags. |
| 6 | templets, profile. |
| 100 | pounds black wax. |
| 4 | wrenches. |
| 50 | pounds wheel grease. |
| 1 | wooden model, 10-inch breech-loading rifle. |
| 25 | boundary posts, cast-iron. |
| 6 | grindstones, crank, etc. |
| 12 | bolts and nuts. |
| 25 | wheel-grease can knives. |
| 2 | dust pans. |

# APPENDIX 2.

## *Statement of principal articles procured by purchase during the year ended June 30, 1891.*

### CLASS I.

| | |
|---|---|
| 1 | Hotchkiss mountain gun, caliber 3-inch. |
| 18 | Gatling guns, caliber .45. |
| 1 | Driggs-Schroeder rapid-fire 6-pounder gun, caliber 2.244. |

### CLASS II.

| | |
|---|---|
| 1 | Hotchkiss mountain carriage and limber, caliber 3-inch. |
| 1 | free recoil carriage, seacoast. |
| 1 | Whipple's ammunition vehicle. |

### CLASS III.

| | |
|---|---|
| 39 | baskets for mortar implements. |
| 10 | Accles feed magazines. |
| 1 | loading machine for Hotchkiss 3-inch mountain gun. |
| 1 | set of accessories and spare parts, Hotchkiss 3-inch mountain gun. |
| 1 | set pack saddles, with bridles, etc., for Hotchkiss 3-inch mountain gun. |

### CLASS IV.

| | |
|---|---|
| 4 | 12-inch steel shells for breech-loading mortar. |
| 25 | 11-inch cast-steel shells. |
| 12 | 7-inch cast-steel shells. |
| 100 | 3-inch shells for Hotchkiss mountain gun. |
| 100 | 3-inch shrapnel for Hotchkiss mountain gun. |
| 300 | 3-inch cylindrical shot for Hotchkiss mountain gun. |
| 12 | hand grenades. |

### CLASS VI.

| | |
|---|---|
| 3,000 | Colt's army revolvers, caliber .45. |

### CLASS VII.

| | |
|---|---|
| 12 | Wint adjustable saddles. |
| 5,061 | cavalry saddle blankets. |

| | |
|---|---|
| 12 | currycombs. |
| 5,016 | knives. |
| 5,016 | forks. |
| 5,000 | spoons. |

## CLASS VIII.

| | |
|---|---|
| 75 | pounds blasting powder. |
| 48,029¼ | pounds brown prismatic powder. |
| 143,900 | pounds square-grain powder. |
| 147,031¾ | pounds small-arms powder. |
| 35,000 | pounds powder for field guns. |
| 600,000 | rifle ball cartridges, caliber .50. |
| 20,000 | rifle blank cartridges, caliber .50. |
| 2,405 | pounds gun cotton. |
| 87¾ | pounds emmensite. |
| 200 | percussion fuses. |
| 1,000 | feet safety fuses. |
| 6,000 | pounds sphero-hexagonal powder. |
| 500 | pounds shot. |

## CLASS IX.

| | |
|---|---|
| 15 | hydraulic jacks. |
| 16 | range finders. |
| 1 | telescopic sight. |
| 50 | gold marksman's medals. |
| 1 | Watson hoist. |
| 3 | hand wheels. |
| 4 | single blocks. |
| 10 | double blocks. |
| 2 | triple blocks. |
| 7 | snatch blocks. |
| 25 | differential blocks. |
| 12 | sheaves. |
| 4 | trolleys. |

## CLASS X.

| | |
|---|---|
| 15,197 | parts of Colt's revolvers, caliber .45. |
| 48 | parts of Parker shotguns. |
| 13 | parts of Gatling gun, model 1883. |
| 1 | pintle for 12-inch carriage. |
| 1 | brass step for 12-inch mortar. |
| 4 | sets appendages for Colt's revolver, caliber .38. |
| 46,569 | black walnut gun stocks. |
| 375 | Archibald artillery wheels. |
| 172 | tubular steel axles. |
| 432 | grommets. |
| 113 | pounds escutcheon pins. |
| 67,140 | escutcheon pins. |
| 26 | iron bits. |
| 28,344 | roller buckles. |
| 17,804 | halter bolts. |
| 10,440 | halter squares. |
| 14,648 | iron rings. |

| | |
|---|---|
| 408 | spring snaps. |
| 18 | forage cap badges. |
| 6, 078 | wooden staves for stirrups. |
| 112 | singletrees. |
| 56 | doubletrees. |
| 72 | neck yokes. |
| 140 | copper recorders for chronograph. |
| 103½ | yards gold lace. |

## *PART SECOND.*

### CLOTH, ROPE, THREAD, ETC.

| | |
|---|---|
| 617 | yards burlaps. |
| 376¾ | yards canvas. |
| 123 | yards carpeting. |
| 57, 309¾ | yards cotton cloth. |
| 14 | yards cloth, enameled and oiled. |
| 27 | yards cloth, rubber. |
| 4¼ | pounds cloth, rubber. |
| 60 | yards cloth, woolen. |
| 966⅜ | yards cloth, felt. |
| 5⅑ | yards cloth, asbestos. |
| 25 | yards flannel, canton. |
| 280¼ | yards flannel, woolen. |
| 10, 008 | yards woolen serge. |
| 10, 573 | pounds cotton waste. |
| 1, 839⅞ | pounds cord and twine. |
| 1, 039 | yards cord and twine. |
| 2, 307 | pounds hair. |
| 369 | pounds marline. |
| 187¾ | yards matting. |
| 4 | door mats. |
| 695 | pounds oakum and tow. |
| 21, 543½ | pounds rope. |
| 28¾ | pounds silk, sewing. |
| 2, 038 | pounds thread. |
| 354 | spools thread. |
| 71 | yards toweling. |
| 24 | towels. |
| 58, 896¼ | yards webbing. |
| 447¾ | pounds yarn. |
| 600 | feet spun yarn. |
| 4, 341 | pounds jute. |
| 100 | yards tape. |
| 75 | window shades. |

### FORAGE.

| | |
|---|---|
| 5, 639 | pounds barley. |
| 19, 782 | pounds bran. |
| 981¼ | bushels corn. |
| 52½ | barrels flour. |
| 37¼ | bushels grass seed. |
| 11, 400 | pounds ground feed. |
| $166\frac{744}{2000}$ | tons hay. |

| | |
|---|---|
| 26,200 | pounds meal. |
| 8,739¼ | bushels oats. |
| 40 | barrels salt. |
| 1,975 | pounds salt. |
| 48$\frac{222}{2000}$ | tons straw. |

### IRONMONGERY.

| | |
|---|---|
| 530 | pounds Babbitt metal. |
| 6 | bath tubs and fixtures. |
| 52.377 | pounds I and channel beams. |
| 9,633 | bolts. |
| 1,097 | pounds bolts. |
| 1 | boiler. |
| 44 | papers brads. |
| 77 | pounds brads. |
| 648¼ | pounds brass rods. |
| 133,301⅝ | pounds brass, sheet. |
| 105,483¼ | pounds brass, cartridge. |
| 322 | pounds burrs. |
| 44,964 | buttons. |
| 2,251⅛ | pounds brass and bronze castings. |
| 163,897 | pounds iron castings. |
| 11,421¾ | pounds steel castings. |
| 1,720½ | pounds chain. |
| 4,900 | feet chain. |
| 57,866¾ | pounds copper, bar. |
| 21,946½ | pounds copper, cartridge. |
| 22,068¾ | pounds copper, sheet. |
| 381 | cocks, assorted. |
| 8 | sets couplings. |
| 60 | couplings. |
| 24 | escutcheons. |
| 203 | door catches and fixtures. |
| 1,718,172 | eyelets. |
| 244 | gas burners and fixtures. |
| 1 | pound glaziers' points. |
| 4 | papers glaziers' points. |
| 241 | pennyweights gold. |
| 3,315 | pairs hinges. |
| 1.400 | hooks, assorted. |
| 5.907 | horseshoes. |
| 1,808 | pounds horseshoe nails. |
| 19 | hose fittings and fixtures. |
| 20 | sets hose fittings and fixtures. |
| 281$\frac{1055}{2240}$ | tons iron, pig. |
| 3.898 | pounds iron, hoop and band. |
| 26.759¾ | pounds iron, sheet. |
| 534.900 | pounds iron, wrought. |
| 50 | feet chain iron, wrought. |
| 242 | knobs, assorted. |
| 24 | sets knobs, assorted. |
| 252 | keys and blanks. |
| 454,836½ | pounds lead. |
| 1,176 | locks, assorted. |
| 51,195½ | pounds nails. |

| | |
|---|---|
| 7,464 | nails, saddlers'. |
| 1,512 | nuts, assorted. |
| 13,555¾ | pounds nuts. |
| 123 | pulleys. |
| 1,063 | pounds iron pipe. |
| 27,149 | feet iron pipe. |
| 5,043¾ | pounds lead pipe |
| 848 | feet lead pipe. |
| 6 | feet steel pipe. |
| 4,138 | pipe fittings. |
| 706½ | pounds pipe fittings. |
| 18 | pumps. |
| 4 | radiators. |
| 2 | reducers. |
| 61,137 | rivets, assorted. |
| 7,894 | pounds rivets. |
| 190½ | pounds rivets and burrs. |
| 2,075 | feet rope, metallic. |
| 3,110 | gross screws. |
| 867 | screws, lag. |
| 19½ | pounds screws, lag. |
| 2,168 | screw-pins, eyes, etc. |
| 4 | sinks. |
| 460½ | pounds solder. |
| 6 | springs, door. |
| 9,200 | pounds spikes. |
| 107 | pounds staples. |
| 144 | staples. |
| 1,158,495⅞ | pounds steel bar, etc. |
| 24 | steel plates. |
| 5,569 | pounds steel forgings. |
| 12,857½ | pounds steel, sheet. |
| 1,822,000 | tacks, assorted. |
| 492 | pounds tacks. |
| 36,074½ | pounds tin, block. |
| 1,280¾ | pounds tin foil. |
| 94⅕ | boxes tin, sheet. |
| 4,678 | sheets tin. |
| 554⅛ | pounds tubing. |
| 106 | feet tubing. |
| 851¾ | pounds washers. |
| 1,254 | washers. |
| 15 | water closets. |
| 6 | urinals. |
| 6,847½ | pounds brass wire. |
| 210¼ | pounds bronze wire. |
| 679¾ | pounds copper wire. |
| 900 | pounds copper alloy wire. |
| 356¼ | pounds copper-covered wire. |
| 206 | feet copper-covered wire. |
| 103 | pounds copper magnate wire. |
| 11,470½ | pounds copper cartridge wire. |
| 11,262 | pounds iron wire. |
| 1,062 | pounds iron insulated wire. |
| 966 | pounds iron galvanized wire. |
| 694 | pounds iron tinned wire. |

| | |
|---|---|
| 2,000 | feet iron galvanized wire. |
| ½ | pound German silver wire. |
| 300 | pounds steel aluminum wire. |
| 13,974¼ | pounds steel wire. |
| 8,197 | pounds steel tinned wire. |
| 500 | feet waterproof wire. |
| 2⅒ | ounces platinum wire. |
| 658⅔ | yards wire cloth. |
| 5,011½ | feet wire cloth. |
| 4,325 | feet wire grating. |
| 70 | wire net platforms. |
| 63 | window fixtures. |
| 13,038½ | pounds zinc. |
| 17 | anchors. |
| 832 | pounds anchors. |
| 200 | steel ribbands. |
| 54 | hooks and staples. |
| 22½ | pounds hooks and staples. |
| 36 | brackets. |
| 13 | sets casters. |
| 1 | iron heater drum. |
| 67½ | pounds German silver. |
| 851½ | pounds antimony. |
| 12 | fixtures for blinds. |

## LEATHER.

| | |
|---|---|
| 11.000 | feet belt lacing. |
| 202 | pounds black wax. |
| 101 | pounds bristles. |
| 19.634 | feet leather belting. |
| 104 | feet rawhide belting. |
| 6 | sides morocco. |
| 124 | rawhides. |
| 142 | sheep skins. |
| 11,826 | square feet bag leather. |
| 2 | sides bag leather. |
| 31½ | pounds belt leather. |
| 6 | sides bellows leather. |
| 414 | pounds buff leather. |
| 103,378¾ | square feet collar leather. |
| 11 | pounds bridle leather. |
| 6,144 | square feet bridle leather. |
| 493 | sides bridle leather. |
| 372 | square feet enameled leather. |
| 51,391⅝ | pounds harness leather. |
| 19 | pounds hemp leather. |
| 132½ | square feet lace leather. |
| 57 | sides lace leather. |
| 134 | square feet military leather. |
| 180 | pounds sole leather. |
| 303 | pounds polishing leather. |
| 3 | sides calf skins. |
| 73 | pounds walrus leather. |

## LUMBER.

| | |
|---|---|
| 1,008 | feet battens. |
| 596,383½ | feet boards. |
| 38,647 | feet joists. |
| 11,100 | lathes. |
| 888,734½ | feet plank. |
| 415 | posts and rails. |
| 50 | feet posts. |
| 51,371 | feet scantling. |
| 140,500 | shingles. |
| 41 | feet strips. |
| 427,104 | feet timber. |
| 64 | spruce logs. |
| 85 | oak piles. |
| 1 | log boxwood. |
| 6 | pieces lignum-vitæ. |

## BUILDING MATERIALS.

| | |
|---|---|
| 563 | pounds asbestos. |
| 641,257 | bricks. |
| 4,104 | barrels cement. |
| 1,197⅓ | barrels clay. |
| 144 | bushels clay. |
| 12 | doors. |
| 1,974 | feet drain-pipe. |
| 35 | bends and traps. |
| 1,434⅔ | square feet flagging. |
| 3,896½ | feet window glass. |
| 3,403 | lights window glass. |
| 18 | bushels plastering hair. |
| 181 | pounds plastering hair. |
| 559 | barrels lime. |
| 367 | bushels lime. |
| 2,380 | feet moldings. |
| 12 | mantles. |
| 4 | barrels plaster of Paris. |
| 200 | pounds plaster of Paris. |
| 27 | yards wall paper. |
| 48 | rolls wall paper. |
| 2,275 | feet tarred paper. |
| 1,738 | pounds tarred paper. |
| 229 | cubic yards sand. |
| 1,019 | bushels sand. |
| 6,999¾ | cubic yards stone. |
| 9,166$\frac{80}{100}$ | cubic feet stone. |
| 7,131 | slates. |
| 182$\frac{170}{2000}$ | tons fire sand. |
| 1,025 | feet weather strips. |
| 1⅔ | feet tin water conductor. |
| 24 | pairs window sash. |
| 1 | corrugated tin roof. |
| 10 | chimney crocks. |
| 18 | barrels tar and pitch. |
| 417½ | gallons tar and pitch. |
| 66 | yards gravel. |
| 600 | bushels gravel. |

### MATERIALS FOR HEATING, LIGHTING, ETC.

| | |
|---|---|
| 24 | bath-bricks. |
| 17 | quarts blacking for leather. |
| 822 | brooms. |
| 393 | brushes, dusting, etc. |
| 280$\frac{125}{1000}$ | square feet card clothing. |
| 90 | sheets card clothing. |
| 140 | pounds candles. |
| 932 | chamois skins. |
| 134 | barrels charcoal. |
| 32,129½ | bushels charcoal. |
| 4,479$\frac{313}{2240}$ | tons anthracite coal. |
| 4,901$\frac{1842}{2240}$ | tons bituminous coal. |
| 187$\frac{1445}{2240}$ | tons coke. |
| 1,492 | pounds corundum. |
| 701 | corundum and emery wheels. |
| 115½ | reams crocus and emery cloth. |
| 5,456 | pounds crocus and emery. |
| 86¾ | cords firewood. |
| 23 | grates. |
| 18 | grate fixtures. |
| 110 | fire-slabs. |
| 18 | tons kaolin. |
| 209 | lamps. |
| 824 | lamp fixtures. |
| 111 | lanterns. |
| 204 | lantern fixtures. |
| 40½ | pounds lampwick. |
| 505 | lampwicks. |
| 16½ | gross matches. |
| 185 | mops and handles. |
| 179½ | pounds paraffine. |
| 157 | gallons paraffine. |
| 30 | pounds pumice stone. |
| 144 | pounds rottenstone. |
| 105 | pounds rosin. |
| 89¾ | reams sandpaper. |
| 225 | yards sandpaper. |
| 468 | cakes sapolio. |
| 50 | pounds sapolio. |
| 10 | barrels facings, sea coal, etc. |
| 21,603 | pounds facing, sea coal, etc. |
| 2,817½ | pounds soap. |
| 652 | gallons soft soap. |
| 302¼ | pounds sponge. |
| 23 | stoves. |
| 32 | stove fixtures. |
| 10 | pounds stove polish. |
| 44 | papers stove polish. |
| 100 | feet stove pipe. |
| 218½ | pounds stove pipe. |
| 54 | stove-pipe elbows. |
| 1,188 | papers tripoli. |
| 23 | washstands and fixtures. |
| 21,462 | fire-bricks. |

| | |
|---|---|
| 13 | sets fire-bricks. |
| 328$\frac{280}{2000}$ | tons molding sand. |
| 25 | carats diamond powder. |
| 100 | gallons anti-incrustation fluid. |
| 4 | sets washtubs. |
| 2 | barrels sea sand. |
| 1 | pound metal polish. |
| 1 | gallon metal polish. |
| 453 | pounds Putz pomade. |
| 12 | boxes Putz pomade. |

MATERIALS FOR OFFICE USE.

| | |
|---|---|
| 7 | waste baskets. |
| 21 | books, reference, etc. |
| 66 | rubber stamps. |
| 60 | chairs, desks, etc. |
| 141½ | pounds cardboard. |
| 500 | sheets cardboard. |
| 318 | yards drawing paper. |
| 13 | quires drawing paper. |
| 80 | bottles India ink. |
| 6 | pieces India ink. |
| 75 | rubbers, etc. |
| 375 | drawing instruments. |
| 17 | sets drawing instruments. |
| 452$\frac{13}{20}$ | reams paper. |
| 1,205 | sheets paper. |
| 66 | boxes seals. |
| 20,000 | seals. |
| 315½ | yards tracing cloth. |
| 3 | rolls tracing cloth. |
| 576 | thumb tacks. |
| 112¼ | gross pens. |
| 645 | pencils. |
| 12 | steel erasers. |
| 24 | boxes pencil leads. |
| 8 | typewriters, hektographs, etc. |
| 52 | parts typewriters. |
| 325 | bottles ink. |
| 6 | pounds printer's ink. |
| 30,950 | envelopes. |
| 8 | watchman's clocks. |
| 1,412 | dials for watchman's clock. |
| 6 | papers pins. |
| 34 | bottles mucilage. |
| 6 | mucilage stands and brushes. |
| 44 | gross rubber bands. |
| 173 | pounds sealing wax. |
| 1,150 | cards. |
| 40 | ink and desk pads. |
| 216 | pounds roller composition. |
| 7,000 | tags. |
| 52 | sheets bristol board. |
| 32 | sheets stencil board. |
| 5 | pounds stencil board. |

| | |
|---:|---|
| 6 | boxes paper-fasteners. |
| 648 | paper-fasteners. |
| 500 | labels. |
| 1 | letter press and stand. |
| 144 | crayons. |
| 76 | pounds hektograph composition. |
| 1,903 | various articles of stationery. |

### MATERIAL FOR LABORATORY USE.

| | |
|---:|---|
| 240 | bottles, jars, etc. |
| 11 | barometers, thermometers, etc. |
| 108 | corks. |
| 116 | crucibles. |
| 94 | glass tubes. |
| 20 | galvanic batteries. |
| 2,433 | electric batteries and parts of. |
| 1,589 | electrical supplies. |
| 31 | pounds electrical supplies. |
| 302 | photographic materials. |
| 30⅛ | gallons acids. |
| 38,245 | pounds acids. |
| 1,354¾ | gallons alcohol. |
| 50 | gallons anti-lamina. |
| 25 | pounds alum. |
| 140 | pounds aqua-ammonia. |
| 198½ | pounds beeswax. |
| 224 | pounds borax. |
| 100,394 | pounds ground bone. |
| 1,819½ | pounds chemicals, various. |
| 4¾ | gallons chemicals, various. |
| 62 | pounds camphor. |
| 253 | pounds chalk. |
| 22 | pounds chloride of ammonium. |
| 65 | pounds concentrated lye. |
| 54 | cans concentrated lye. |
| 550 | pounds copper and its preparations. |
| 150 | pounds cream of tartar. |
| 400 | pounds electropion fluid. |
| 103 | pounds flaxseed. |
| 50 | pounds Glauber salt. |
| 350 | pounds ground glass. |
| 5 | pounds gelatine. |
| 2,735 | pounds glue. |
| 7 | gallons liquid glue. |
| 275 | pounds glycerine. |
| 25 | pounds gum arabic. |
| 43 | pounds gum tragacanth. |
| 1½ | gallons horse medicine. |
| 2 | pounds horse medicine. |
| 60 | pounds iron and its preparations. |
| 141 | gallons isinglass. |
| 50 | pounds insect powder. |
| 4 | gallons molasses. |
| 10 | pounds mercury and its salts. |
| 241 8/20 | reams paper. |

| | |
|---|---|
| 106,423½ | pounds paper. |
| 262 | rolls paper. |
| 1,613 | yards paper. |
| 905 | pounds potash, various. |
| 3,791 | pounds soda and its preparations. |
| 4½ | pounds sugar of lead. |
| 192 | pounds sal ammoniac. |
| 15,027 | pounds sal soda. |
| 10 | pounds sulphur. |
| 25,000 | pounds straw boards. |
| 27 | gallons tar. |
| 154 | pounds vaseline. |
| 341 | gallons vinegar. |
| 50 | pounds welding compound. |
| 1,295½ | pounds tallow and lard. |

### PAINTS, OILS, ETC.

| | |
|---|---|
| 47 | gallons acme resolvent. |
| 168½ | gallons benzine. |
| 18 | packages bronze powder. |
| 6⅜ | pounds bronze powder. |
| 100 | pounds cosmic. |
| 500 | quarts cosmic. |
| 192¼ | gallons drier. |
| 6 | gallons encaustic. |
| 67,304¾ | gallons gasoline. |
| 30 | pounds hard oil finish. |
| 5 | gallons hard oil finish. |
| 20 | pounds hard wood filler. |
| 625 | pounds kalsomine. |
| 95 | pounds lampblack. |
| 150 | pounds litharge. |
| 39 | pounds extract of logwood. |
| 152 | pounds lead, black. |
| 500 | pounds lead, red. |
| 30,499 | pounds lead, white. |
| 788 | pounds lubricating compound. |
| 1,885½ | gallons naphtha. |
| 10 | pounds nut galls. |
| 2,888 | gallons petroleum and its products. |
| 200 | pounds putty. |
| 9,347 | pounds paint, in oil. |
| 2,475 | pounds paint, dry. |
| 1,056 | pounds shellac. |
| 34 | gallons shellac. |
| 1,457 | gallons spirits of turpentine. |
| 25 | pounds Venice turpentine. |
| 300¼ | gallons varnish. |
| 4,310 | pounds whiting. |
| 1,060¼ | pounds zinc. |
| 5 | gallons harness oil. |
| 39 | gallons castor oil. |
| 50 | gallons cod-liver oil. |
| 207 | gallons dressing oil. |
| 6,382¼ | gallons illuminating oil. |
| 7,457 | gallons lubricating oil. |

| | |
|---|---|
| 13 | bottles lubricating oil. |
| 12,148 | gallons oil, mixing paint. |

### MISCELLANEOUS.

| | |
|---|---|
| 1 | oil cabinet. |
| 1 | gasoline tank. |
| 1 | ice chest. |
| 2 | pumps. |
| 3 | water coolers. |
| 51 | water buckets. |
| 4 | wooden benches. |
| 17 | baskets. |
| 12 | ash cans. |
| 20 | arm chests. |
| 384 | tin cans. |
| 5 | electric belts. |
| 50 | powder kegs. |
| 150 | hoops for powder barrels. |
| 5,500 | pasteboard boxes. |
| 40 | packing boxes. |
| 60 | cords manure. |
| 3 | tons fertilizers. |
| 250 | sponge cloths. |
| 969 | empty sacks. |
| 4,572¼ | pounds Japan wax. |
| 4 | rolls electric tape. |
| 24 | finger cots. |
| 28 | pairs rubber boots. |
| 52 | pairs rubber shoes. |
| 4 | rubber aprons. |
| 1 | rubber coat. |
| 1 | pair rubber gloves. |
| 60 | gallons belt dressing. |
| 50 | pounds belt dressing. |
| 117¼ | pounds gutta percha. |
| 14⅝ | pounds rubber. |
| 500 | feet rubber tubing. |
| 58¾ | pounds rubber tubing. |
| 2 | rolls sand cloth. |
| 16 | horse blankets. |
| 1 | carriage robe. |
| 8 | pair car wheels. |
| 9 | whips. |
| 115 | rubber rings, etc. |
| 160¾ | pounds rubber gaskets, etc. |
| 4 | store trucks. |
| 1 | dump cart. |
| 21 | parts of wagons. |
| 1 | drag scraper. |
| 5 | horses. |
| 2,536⅜ | pounds packing, various. |
| 5,238 | feet rubber and canvas hose. |
| 440 | pounds axle grease. |
| 3 | sets cart harness. |
| 419 | parts of harness. |
| 293 | railroad tickets. |

## MACHINES.

| | |
|---|---|
| 3 | galvanometers. |
| 6 | steam engines. |
| 2 | steam meters. |
| 8 | steam boilers. |
| 3 | steam pumps. |
| 4 | parts of steam pumps. |
| 1 | acid pump. |
| 3 | smoke stacks. |
| 1 | cupola furnace. |
| 10 | agricultural machines, various. |
| 92 | parts agricultural machines. |
| 1,024½ | pounds shafting. |
| 5 | portable double-chain screw hoisting machines. |
| 1 | No. 2 tool grinder. |
| 1 | No. 4 tool grinder. |
| 1 | 32-inch vertical drilling machine. |
| 1 | 18-inch stroke shaping machine, complete. |
| 2 | 30-ton overhead traveling cranes, complete. |
| 1 | derrick-winch. |
| 1 | 24-inch engine lathe, complete. |
| 1 | steel pressure blower. |
| 1 | bevel protractor. |
| 1 | gas generator. |
| 2 | injector blowers. |
| 1 | No. 6 universal trimmer. |
| 2 | 72-inch vertical boring mills. |
| 6 | 60-inch vertical boring mills. |
| 1 | 60 by 48 inch lathe, 24-foot bed. |
| 1 | 60 by 48 inch lathe, 20-foot bed. |
| 1 | 60 by 48 inch lathe, 18-foot bed. |
| 2 | 48 inch lathes, 10-foot bed. |
| 4 | 20-inch lathes. |
| 1 | 26½-inch planer. |
| 1 | 32½-inch planer. |
| 1 | 38½-inch planer. |
| 1 | 44½-inch planer. |
| 1 | universal radial drilling machine. |
| 1 | 60-inch horizontal boring and drilling machine. |
| 1 | milling machine. |
| 1 | gumming machine. |
| 1 | steam hammer. |
| 2 | cylinder boring machines. |
| 1 | 24-inch slotter. |
| 1 | 18-inch slotter. |
| 4 | 18-inch shapers. |
| 1 | No. 2 steel road scraper. |
| 1 | injector. |
| 1 | feed-water heater. |
| 1 | 72-inch lathe. |
| 2 | 42-inch lathes. |
| 1 | emery wheel aggravator and 3 sets cutters. |
| 1 | rein rounder. |
| 1 | portable drill. |
| 3 | 16-inch standard screw-cutting engine lathes. |

| | |
|---|---|
| 1 | drill press. |
| 1 | power punching press. |
| 1 | self-opening slip roll former, extra heavy. |
| 1 | back-geared power shear, extra heavy. |
| 1 | 18-inch leather-splitting machine. |
| 1 | 16-inch by 8-foot engine lathe. |
| 1 | milling machine. |
| 1 | horizontal boring, drilling, and milling machine. |
| 1 | Queen's portable testing and resistance set. |
| 1 | angular ratchet drilling machine. |
| 4 | Singer's sewing machines. |
| 1 | bar-iron cutter, complete. |
| 1 | rotary washing machine. |
| 1 | drying machine. |
| 1 | wood-turning lathe. |
| 1 | emery wheel tool-grinder. |
| 1 | slotting machine. |
| 1 | shaping machine. |
| 1 | fan-flower. |
| 1 | geared power trimming and squaring shear. |
| 4 | annealing retorts. |
| 1 | Brush dynamo. |
| 1 | 24 by 10 inch engine lathe. |
| 7 | engine lathes. |
| 1 | emery saw-sharpener. |
| 2 | threading and slotting machines. |
| 1 | 21-inch engine lathe, 10-foot bed. |
| 1 | 31-inch engine lathe, 15-foot bed. |
| 1 | No. 2 vertical milling machine. |
| 1 | 2-spindle profiling machine. |
| 1 | 32-inch swing engine lathe. |
| 2 | engine lathes. |
| 1 | cutting-off and finishing machine. |

### INSPECTING INSTRUMENTS.

| | |
|---|---|
| 35 | surveyors' and engineers' instruments. |
| 59 | glass levels. |
| 2 | time-interval recorders. |
| 7 | sets base measuring apparatus. |
| 7 | calipers. |
| 5 | steel rules. |
| 9 | chronographs. |

### TOOLS.

| | |
|---|---|
| 34 | awls. |
| 98 | axes. |
| 6 | augers. |
| 115 | bits. |
| 2 | braces. |
| 134 | buckets, pails, etc. |
| 1,906 | brushes and sash tools. |
| 42 | chisels. |
| 2,593 | pounds chalk lines. |
| 12 | chalk lines. |

| | |
|---|---|
| 1,121 | carpenter's tools, various. |
| 23 | coal hods. |
| 48 | dies. |
| 296 | drills. |
| 36 | set drills. |
| 150 | drifts. |
| 6,685 | files. |
| 51 | forks, hay and manure. |
| 27 | gauges. |
| 6 | gouges. |
| 56,594 | pounds grindstones. |
| 4 | grindstone frames. |
| 178 | hatchets and hammers. |
| 2,338 | handles, assorted. |
| 27 | hoes. |
| 1 | inspirator (Hancock's). |
| 128 | knives. |
| 26 | levels. |
| 2 | ladders. |
| 231 | machinist's tools, various. |
| 11 | sets machinist's tools, various. |
| 125 | mallets. |
| 12 | nippers. |
| 1 | nail puller. |
| 159 | oil cups and oilers. |
| 139 | oil stoves. |
| 34 | picks. |
| 117 | punches, assorted. |
| 183 | rakes. |
| 160 | rasps. |
| 61 | rules. |
| 122 | smith's tools, various. |
| 11 | squares. |
| 53 | sieves and sifters. |
| 141 | saws. |
| 226 | saw blades. |
| 10 | scales. |
| 16 | pairs shears. |
| 346 | spades and shovels. |
| 63 | scythes. |
| 96 | scythe stones. |
| 26 | scythe snaths. |
| 126 | stamps. |
| 26 | sets stamps. |
| 2 | sets letters and figures. |
| 122 | saddler's tools, various. |
| 2 | sets graining combs. |
| 51 | tools, various. |
| 1 | tinner's furnace. |
| 3 | pairs tinner's snips. |
| 17 | tape lines. |
| 91 | utensils, various. |
| 36 | vises. |
| 1 | wooden pump. |
| 231 | wrenches. |
| 51 | wheelbarrows. |

# APPENDIX 3.

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*Statement of ordnance, ordnance stores, etc., issued to the military establishment, including the national homes for soldiers of the volunteer and regular Army, and exclusive of the militia, during the fiscal year ended June 30, 1891.*

## CLASS I.

| | |
|---|---|
| 4 | Gatling guns, 10-long barrels, caliber .45. |
| 2 | Hotchkiss revolving cannon, caliber 1″.50. |
| 7 | Hotchkiss mountain guns, caliber 1″.65. |
| 4 | 3-inch rifled guns. |
| 1 | 3.2-inch breech-loading steel rifle. |
| 11 | 8-inch converted rifles. |

## CLASS II.

| | |
|---|---|
| 4 | Gatling gun carriages and limber. |
| 2 | Hotchkiss revolving gun carriages and limber. |
| 7 | Hotchkiss mountain gun carriages. |
| 4 | 3-inch gun carriages and limbers. |
| 4 | 3-inch gun carriages without limber. |
| 1 | 3.2-inch gun carriage and limber. |
| 2 | 4.5-inch siege-gun carriages without limbers. |
| 1 | 5-inch gun steel carriage. |
| 4 | 8-inch barbette carriages and chassis, hydraulic cylinders. |
| 1 | 12-inch breech-loading rifle barbette carriage and chassis. |
| 1 | 15-inch barbette carriage and chassis, hydraulic cylinder. |
| 4 | 3.2-inch gun caissons and limbers, new model. |
| 1 | ammunition vehicle. |
| 2 | ammunition wagons, Hotchkiss cannon. |
| 12 | field-gun carriage limbers. |
| 1 | siege-gun carriage limber. |
| 1 | mortar bed, unserviceable. |
| 1 | forge and battery wagon combined. |
| 2 | portable forges. |
| 2 | forge chests. |

## CLASS III.

| | |
|---|---|
| 31 | baskets mortar implements. |
| 1 | sponge bucket. |
| 144 | canvas water buckets. |
| 21 | iron water buckets. |
| 15 | gutta percha water buckets. |

| | |
|---|---|
| 1 | rubber water bucket. |
| 2 | cannon-muzzle hoods. |
| 1 | dredging box. |
| 1 | elevating bar. |
| 31 | funnels. |
| 1 | fuse cutter. |
| 1 | fuse gauge. |
| 1 | fuse gouge. |
| 4 | fuse mallets. |
| 12 | fuse wrenches. |
| 3 | gunners' calipers. |
| 45 | gunners' gimlets. |
| 40 | gunners' haversacks. |
| 9 | gunners' levels. |
| 4 | gunners' pincers. |
| 4 | gunners' pouches. |
| 27 | gunners' quadrants. |
| 13 | gunners' reamers. |
| 16 | gunners' sleeves. |
| 57 | maneuvering handspikes. |
| 18 | mortar handspikes. |
| 8 | rear handspikes. |
| 6 | roller handspikes. |
| 12 | shod handspikes. |
| 16 | trail handspikes. |
| 32 | sets harness, 2 lead horses. |
| 34 | sets harness, 2 wheel horses. |
| 1 | set harness, Gatling gun cart. |
| 5 | sets harness, Hotchkiss mountain gun. |
| 79 | harness sacks. |
| 5 | knapsack boots. |
| 10 | ladles and staves. |
| 1 | globe lantern. |
| 6 | magazine lanterns. |
| 5 | tubular lanterns, brass. |
| 92 | lanyards. |
| 4 | maneuvering bars. |
| 4 | mauls. |
| 18 | muzzle covers and straps. |
| 1 | muzzle cover and tompion, 3.2-inch steel gun. |
| 31 | pass boxes. |
| 2 | paulins, 6 by 10 feet. |
| 6 | paulins, 8 by 10 feet. |
| 12 | paulins, 11 by 11 feet. |
| 18 | paulins, 12 by 15 feet. |
| 3 | pendulum hausses. |
| 1 | pendulum hausse pouch. |
| 3 | pendulum hausse seats. |
| 11 | pinch bars. |
| 3 | plummets. |
| 1 | pointing stake. |
| 8 | powder funnels. |
| 18 | powder measures. |
| 4 | powder scoops. |
| 2 | primer pouches. |

| | |
|---|---|
| 108 | priming wires. |
| 23 | prolonges. |
| 36 | rammers and staves, 8-inch gun. |
| 6 | rammers and staves, 10-inch gun. |
| 2 | rammers and staves, 11-inch gun. |
| 2 | rammers and staves, 15-inch gun. |
| 8 | cannon scrapers. |
| 4 | carriage scrapers. |
| 1 | combination screw-driver, 3.2-inch gun. |
| 2 | shell hooks. |
| 2 | shot-carrying bars. |
| 10 | shot hooks. |
| 4 | front sights, 3.2-inch gun. |
| 2 | front sights, 3.6-inch gun. |
| 19 | front sights, 8-inch gun. |
| 1 | front-sight cover, 3.2-inch gun. |
| 1 | rear sight, 3-inch gun. |
| 5 | rear sights, 3.2-inch gun. |
| 2 | rear sights, 3.6-inch gun. |
| 24 | rear sights, 8-inch gun. |
| 1 | rear-sight cover, 3.2-inch gun. |
| 8 | rear-sight pouches. |
| 11 | rear-sight seats. |
| 6 | sponge covers, 6-pounder. |
| 10 | sponge covers, 12-pounder. |
| 6 | sponge covers, 3-inch. |
| 5 | sponge covers, 3.2-inch bore. |
| 10 | sponge covers, 3.2-inch chamber. |
| 42 | sponge covers, 8-inch. |
| 6 | sponge covers, 10-inch. |
| 6 | sponges and rammers, 6-pounder gun. |
| 20 | sponges and rammers, 12-pounder gun. |
| 1 | sponge and rammer, 12-pounder mountain howitzer. |
| 52 | sponges and rammers, 3-inch gun. |
| 15 | sponges and rammers, 3.2-inch gun, long. |
| 2 | sponges and rammers, 3.2-inch gun, short. |
| 36 | sponges and staves, 8-inch gun. |
| 6 | sponges and staves, 10-inch gun. |
| 1 | sponge and staff, 11-inch gun. |
| 8 | sponges and staves, 15-inch gun. |
| 1 | sponge and staff, 13-inch mortar. |
| 54 | thumbstalls. |
| 7 | tompions, 12-pounder gun. |
| 4 | tompions, 3-inch gun. |
| 16 | tompions, 8-inch gun. |
| 3 | tompions, 15-inch gun. |
| 3 | tompions, 10-inch mortar. |
| 48 | tube pouches. |
| 72 | vent covers. |
| 27 | vent pieces. |
| 2 | vent punches, field gun. |
| 19 | vent punches, siege gun. |
| 20 | water tubs. |
| 11 | wipers for mortar. |
| 14 | worms and staves. |

### IMPLEMENTS FOR GATLING GUN.

| | |
|---|---|
| 2 | clamps for worm-gear. |
| 4 | drifts. |
| 12 | feed guides. |
| 3 | gun covers. |
| 16 | haversacks. |
| 3 | oilers. |
| 5 | lock screw-drivers. |
| 5 | small screw-drivers. |
| 5 | T screw-drivers. |
| 5 | shell-drivers. |
| 1 | trunnion bed. |
| 5 | wiping rods. |
| 2 | adjusting screw wrenches. |
| 4 | cascabel plate wrenches. |
| 4 | pin-nut wrenches. |
| 5 | pin wrenches. |
| 5 | rear guide nut wrenches. |
| 2 | sets accessories for ammunition wagon. |

### ACCESSORIES HOTCHKISS MOUNTAIN GUN.

| | |
|---|---|
| 6 | sets accessories complete. |
| 1 | breech cover. |
| 4 | cleaning brushes. |
| 6 | gun covers. |
| 1 | muzzle cover. |
| 3 | oil cans. |
| 10 | packing outfits. |
| 2 | rammers and staves. |
| 2 | screw-drivers. |
| 3 | sights. |
| 1 | sponge and staff. |
| 3 | breech-block stops. |
| 2 | stop keys. |
| 3 | vent gauges. |
| 1 | wiping brush. |

### CLASSES IV AND V.

| | |
|---|---|
| 54 | 30-pounder shot. |
| 100 | 3-inch shot. |
| 468 | 4.5-inch shot. |
| 20 | 8-inch breech-loading rifle shot. |
| 256 | 8-inch cored shot. |
| 1 | 10-inch breech-loading rifle shot. |
| 62 | 10-inch cored shot. |
| 1 | 12-inch breech-loading rifle shot. |
| 1 | 12.25-inch muzzle-loading rifle shot. |
| 210 | 15-inch gun shot. |
| 1,000 | 1.5-inch revolving gun shell. |
| 872 | 1.65-inch mounting gun shell. |
| 200 | 3-inch rifle shell. |
| 1,513 | 3.2-inch rifle shell. |
| 595 | 4.5-inch shell. |

| | |
|---|---|
| 28 | 30-pounder Parrott shell. |
| 1 | 5-inch breech-loading rifle shell. |
| 1 | 7-inch breech-loading howitzer shell. |
| 100 | 8-inch converted rifle shell. |
| 170 | 8-inch muzzle-loading rifle shell. |
| 1 | 3.6-inch mortar shell. |
| 88 | 8-inch mortar shell. |
| 18 | 10-inch mortar shell. |
| 201 | 12-inch breech-loading mortar shell. |
| 1 | 12-inch muzzle-loading mortar shell. |
| 150 | 13-inch mortar shell. |
| 677 | 1.65-inch canister. |
| 495 | 1.65-inch case shot. |

## CLASS VI.

| | |
|---|---|
| 1,237 | Springfield carbines, caliber .45. |
| 3,106 | Springfield rifles, caliber .45. |
| 105 | Springfield rifles, rod bayonet, caliber .45. |
| 1 | Springfield rifle, cavalry and infantry, experimental. |
| 99 | Springfield shot guns. |
| 96 | Colt's revolvers, caliber .38. |
| 968 | Colt's revolvers, caliber .45. |
| 31 | Schofield-Smith and Wesson revolvers, caliber .45. |
| 96 | Smith and Wesson revolvers, caliber .38. |
| 1 | Chaffee-Reece magazine rifle. |
| 1 | Hotchkiss magazine rifle. |
| 1 | Lee magazine rifle. |
| 17 | light artillery sabers. |
| 180 | light cavalry sabers. |
| 54 | light cavalry sabers, foreign. |
| 73 | musicians' swords. |
| 39 | non-commissioned officers' swords. |
| 106 | hospital corps knives. |
| 968 | hunting knives. |

## CLASS VII.

### APPENDAGES.

| | |
|---|---|
| 12 | brushes and thongs. |
| 6 | cleaning rods. |
| 32 | drifts, caliber .38 revolvers. |
| 3,904 | headless shell extractors. |
| 8 | ratchet-sets. |
| 1,696 | combination screw-drivers. |
| 563 | revolver screw-drivers. |
| 153 | spring vises. |
| 557 | tumbler-punches. |
| 1,261 | carbine wiping rods. |
| 4,194 | rifle wiping rods. |
| 67 | revolver wiping rods, caliber .45. |
| 96 | revolver wiping brushes, caliber .38. |
| 96 | revolver wiping rods, caliber .38. |
| 8 | revolver wrenches, caliber .38. |

### ARTILLERY ACCOUTERMENTS.

| | |
|---|---|
| 40 | knapsacks. |
| 145 | saber belts. |
| 171 | saber-belt plates. |

### CAVALRY EQUIPMENTS.

| | |
|---|---|
| 1,433 | canteen straps. |
| 1,265 | carbine cartridge belts. |
| 100 | revolver cartridge belts. |
| 65 | revolver cartridge pouches. |
| 687 | carbine slings. |
| 775 | carbine-sling swivels. |
| 1,268 | revolver holsters. |
| 591 | saber attachments. |
| 1,285 | saber belts. |
| 497 | saber-belt plates. |
| 1,649 | saber knots. |

### INFANTRY EQUIPMENTS.

| | |
|---|---|
| 2,021 | bayonet scabbards, Hoffman attachment. |
| 1,571 | bayonet scabbards, hook attachment. |
| 2,638 | blanket bags. |
| 4,537 | blanket-bag coat straps. |
| 5,026 | blanket-bag shoulder straps. |
| 5,291 | canteens. |
| 3,400 | canteen straps. |
| 71 | cap pouches. |
| 3,733 | cartridge belts. |
| 2,616 | cartridge-belt plates. |
| 65 | cartridge boxes, cadet. |
| 3,319 | cartridge boxes, McKeever. |
| 1,749 | clothing bags and straps. |
| 4,221 | knives. |
| 3,336 | forks. |
| 3,309 | spoons. |
| 109 | sliding frogs. |
| 4,982 | gun slings. |
| 5,140 | haversacks. |
| 4,300 | haversack straps. |
| 3,625 | meat cans. |
| 106 | hospital-corps knife scabbards. |
| 681 | hunting-knife scabbards. |
| 67 | intrenching-tool scabbards. |
| 4,234 | tin cups. |
| 20 | cadet waist-belt plates. |
| 159 | non-commissioned officers' waist belts. |
| 145 | non-commissioned officers' waist-belt plates. |
| 1,872 | waist belts. |
| 2,373 | waist-belt plates. |

### HORSE EQUIPMENTS.

| | |
|---|---|
| 2,401 | curb bridles. |
| 528 | watering bridles. |

| | |
|---:|---|
| 1,035 | carbine boots and straps. |
| 235 | cinchas. |
| 2,454 | currycombs. |
| 1,719 | halters and straps. |
| 1,208 | halter headstalls. |
| 4,687 | halter straps. |
| 3,286 | horse brushes. |
| 859 | horse covers. |
| 2,051 | lariats. |
| 820 | links. |
| 2,569 | nose-bags. |
| 844 | picket-pins. |
| 967 | leather-covered saddles. |
| 1,340 | rawhide-covered saddles. |
| 12 | Wint's saddles. |
| 18 | canvas saddlebags. |
| 720 | leather saddlebags. |
| 1,510 | artillery saddle blankets. |
| 2,710 | cavalry saddle blankets. |
| 171 | cotton saddle cloths, red. |
| 88 | hair saddle cloths. |
| 595 | side lines. |
| 3,280 | spurs. |
| 2,428 | spur straps. |
| 1,424 | stirrups. |
| 7 | stirrups with guidon sockets. |
| 649 | stirrup straps. |
| 1,013 | surcingles. |

## CLASS VIII.

### SMALL-ARM CARTRIDGES, ETC.

| | |
|---:|---|
| 891,120 | carbine ball cartridges, caliber .45. |
| 1,036,810 | rifle ball cartridges, caliber .45. |
| 527,600 | rifle and carbine blank cartridges, caliber .45. |
| 7,000 | rifle blank cartridges, caliber .50. |
| 739,872 | revolver ball cartridges, caliber .45. |
| 386,970 | revolver blank cartridges, caliber .45. |
| 48,000 | revolver ball cartridges, caliber .38. |
| 1,676,600 | carbine bullets. |
| 2,977,266 | rifle bullets. |
| 411,550 | revolver bullets. |
| 64,575 | round balls. |
| 56,271 | pounds small-arms powder. |
| 7,370 | pounds shot. |
| 7,508,500 | cartridge primers. |
| 200 | cartridge shells, unfinished. |
| 6,075 | cartridge shells, No. 20. |
| 212,800 | wads, shotgun. |

### AMMUNITION FOR CANNON.

| | |
|---:|---|
| 1,000 | blank cartridges, ½-pound charge. |
| 32,625 | blank cartridges, 1-pound charge. |
| 4,395 | blank cartridges, 1¾-pounds charge. |

| | |
|---:|---|
| 3, 100 | blank cartridges, 2½-pounds charge. |
| 3, 500 | blank cartridges, 3¾-pounds charge. |
| 3, 676 | blank cartridges, 6-pounder gun. |
| 17, 150 | blank cartridges, 12-pounder gun. |
| 1, 684 | blank cartridges, mountain howitzer. |
| 86 | combination fuses. |
| 805 | percussion fuses. |
| 501 | time fuses. |
| 238 | wood fuses. |
| 24, 700 | pounds cannon powder. |
| 13, 500 | pounds mammoth powder. |
| 25 | pounds mealed powder. |
| 13, 800 | pounds mortar powder. |
| 14, 420 | pounds oriental hexagonal powder. |
| 17, 540 | pounds sphero-hexagonal powder. |
| 3, 301 | electric primers. |
| 41 | electric obturating primers. |
| 150, 859 | friction primers. |

## CLASS IX.

| | |
|---:|---|
| 14 | sets azimuth instruments, complete. |
| 7 | sets base measuring apparatus. |
| 3 | blocks, double. |
| 55 | blocks, half. |
| 51 | blocks, quarter. |
| 5 | blocks, single. |
| 5 | blocks, snatch. |
| 2 | blocks, triple. |
| 89 | blocks, whole. |
| 288 | blocks, wood, various sizes. |
| 1 | set bolsters and caps for gun lift. |
| 1 | set bolts and keys for gun lift. |
| 152 | bolts and nuts for mortar platform. |
| 1 | capstan barrel. |
| 11 | capstan holdfasts. |
| 1 | cap shears. |
| 20 | chocks, casemate. |
| 144 | chocks, gun. |
| 90 | chocks, roller. |
| 113 | chocks, wheel. |
| 3 | cradles. |
| 18 | cradle rollers. |
| 9 | cranes, loading. |
| 6 | floor boards, gun carriage. |
| 3 | gins, garrison. |
| 1 | gin, Piper's. |
| 3 | gin falls. |
| 7 | gin handspikes. |
| 6 | gin shoes. |
| 3 | gin slings. |
| 2 | hand barrows. |
| 1 | hand-cart. |
| 141 | halliards. |
| 30 | hat ornaments, cadet. |
| 8 | hydraulic jacks, lifting. |

| | |
|---|---|
| 1 | hydraulic jack, pulling. |
| 7 | intrenching tools. |
| 3 | magnetic firing machines. |
| 400 | marksman's buttons. |
| 400 | marksman's pins. |
| 2 | mortar wagons. |
| 4 | planks, gun-lift staging. |
| 20 | planks, shifting. |
| 38 | planks, way. |
| 10 | platforms, gun. |
| 16 | platforms, mortar. |
| 4 | pulleys, differential. |
| 7 | pulleys, hoisting. |
| 1 | range and position finder (Fiske). |
| 14 | range finders (Pratt's). |
| 3 | sling carts. |
| 3 | sling-cart poles. |
| 1 | sling-cart wheel. |
| 6 | sling chains. |
| 143 | rollers. |
| 255 | sharpshooters' badges. |
| 239 | sharpshooters' badge silver bars. |
| 3 | shears, gun lift. |
| 18 | skids. |
| 4 | time-interval recorders. |
| 30 | trace ropes. |
| 7 | transits, engineers'. |
| 2 | trestles, mortar. |
| 2 | trunnion chains. |
| 11 | trunnion rings and keys, eccentric. |
| 150 | washers, platform. |

### TARGETS, TARGET MATERIAL, ETC.

| | |
|---|---|
| 25 | marking staves and disks. |
| 122 | shot marks and staves. |
| 142 | signal flags. |
| 158 | streamers. |
| 1 | target, artillery, land. |
| 27 | targets, Brinton. |
| 32 | targets, floating and towing. |
| 14 | targets, iron, gallery practice. |
| 200 | targets, Laidley. |
| 33,865 | targets, paper. |
| 72 | angle irons. |
| 145 | axles. |
| 1 | axle bolt. |
| 2 | axle-bolt caps. |
| 4 | axle washers. |
| 24 | blocks, spring. |
| 304 | bolts and nuts. |
| 1 | brace. |
| 1,435 | centers. |
| 45 | centers, revolving. |
| 13 | clamps. |
| 6 | clevises. |

| | |
|---|---|
| 257 | cross pieces. |
| 76 | frames, Brinton. |
| 38 | frames, Cushing. |
| 15 | frames, rolling. |
| 965 | frames, steel. |
| 831 | frames, wood. |
| 190 | journal boxes. |
| 365 | journal-box pins. |
| 26 | journal-box posts. |
| 938 | keys or wedges, wood. |
| 42 | levers. |
| 166 | lever blocks. |
| 2 | lock bolts. |
| 2 | lock-bolt plates. |
| 175 | nave boxes. |
| 6 | open links. |
| 12, 959, 000 | pasters. |
| 378 | pins, wood. |
| 1 | pulley. |
| 151 | rails. |
| 20, 228 | silhouettes, cloth. |
| 103, 818 | silhouettes, paper. |
| 4 | sills. |
| 8 | sill stakes. |
| 2 | spring loops. |
| 7, 710 | strings. |
| 2 | swivels. |
| 361 | uprights. |

### RELOADING TOOLS, ETC.

| | |
|---|---|
| 5 | sets bench reloading tools, complete. |

### SHELL RESIZING TOOLS AND PARTS.

| | |
|---|---|
| 2 | shell resizing tools. |
| 2 | cartridge-head adjusting screws. |
| 6 | cartridge-head adjusting screw nuts. |
| 1 | disk. |
| 107 | dies, lower. |
| 101 | dies, upper, revolver. |
| 658 | dies, upper, rifle. |
| 2 | lever pins. |
| 2 | lever-pin screws. |
| 4 | links. |
| 10 | link pins. |
| 10 | link-pin screws. |
| 16 | rings. |
| 15 | spindles. |
| 2 | stands. |

### ASSEMBLING AND CRIMPING TOOLS AND PARTS.

| | |
|---|---|
| 1 | assembling and crimping tool. |
| 8 | check levers. |
| 7 | check-lever springs. |

| | |
|---|---|
| 8 | check-lever spring screws. |
| 34 | dies. |
| 1 | die holder. |
| 3 | die-holder set screws. |
| 2 | die-holder stop screws. |
| 1 | die lever. |
| 3 | die-lever pins. |
| 2 | die-holder guides. |
| 4 | die-holder guide screws. |
| 2 | links. |
| 2 | link pins. |
| 2 | shell rests. |
| 4 | shell rest holder plates. |
| 8 | shell rest holder plate screws. |
| 6 | shell rest set screws. |
| 6 | stems, carbine and rifle. |
| 1 | stem, revolver. |
| 1 | stem carrier. |
| 1 | stem lever. |
| 4 | stem-lever pins. |
| 14 | stem-lever pin screws. |
| 17 | stem screws. |

### POWDER-CHARGING TOOLS AND PARTS.

| | |
|---|---|
| 2 | powder-charging tools. |
| 3 | charges and dies. |
| 4 | charger slides and screws. |
| 4 | receivers and funnels. |
| 2 | receiver nuts. |
| 3 | wrenches. |

### PRIMER-EXTRACTING TOOLS AND PARTS.

| | |
|---|---|
| 2 | primer-extracting tools. |
| 346 | extractor pins. |
| 11 | levers. |
| 9 | lever pins. |
| 13 | spindles. |
| 13 | spindle screws. |

### PARTS PRIMER-INSERTING TOOLS.

| | |
|---|---|
| 8 | bushings, carbine and rifle. |
| 6 | bushings, revolver. |
| 1 | bushing screw. |
| 3 | ejector pins. |
| 8 | pinion levers. |
| 6 | pinion-lever pins. |
| 2 | pin wrenches. |
| 8 | primer setters. |
| 1 | stand. |

### PARTS HAND-RELOADING TOOLS.

| | |
|---|---|
| 15 | ball molds. |
| 19 | brush wipers. |
| 20 | powder and shot chargers. |

### IMPLEMENTS FOR GATLING GUN.

| | |
|---|---|
| 2 | clamps for worm-gear. |
| 4 | drifts. |
| 12 | feed guides. |
| 3 | gun covers. |
| 16 | haversacks. |
| 3 | oilers. |
| 5 | lock screw-drivers. |
| 5 | small screw-drivers. |
| 5 | T screw-drivers. |
| 5 | shell-drivers. |
| 1 | trunnion bed. |
| 5 | wiping rods. |
| 2 | adjusting screw wrenches. |
| 4 | cascabel plate wrenches. |
| 4 | pin-nut wrenches. |
| 5 | pin wrenches. |
| 5 | rear guide nut wrenches. |
| 2 | sets accessories for ammunition wagon. |

### ACCESSORIES HOTCHKISS MOUNTAIN GUN.

| | |
|---|---|
| 6 | sets accessories complete. |
| 1 | breech cover. |
| 4 | cleaning brushes. |
| 6 | gun covers. |
| 1 | muzzle cover. |
| 3 | oil cans. |
| 10 | packing outfits. |
| 2 | rammers and staves. |
| 2 | screw-drivers. |
| 3 | sights. |
| 1 | sponge and staff. |
| 3 | breech-block stops. |
| 2 | stop keys. |
| 3 | vent gauges. |
| 1 | wiping brush. |

### CLASSES IV AND V.

| | |
|---|---|
| 54 | 30-pounder shot. |
| 100 | 3-inch shot. |
| 468 | 4.5-inch shot. |
| 20 | 8-inch breech-loading rifle shot. |
| 256 | 8-inch cored shot. |
| 1 | 10-inch breech-loading rifle shot. |
| 62 | 10-inch cored shot. |
| 1 | 12-inch breech-loading rifle shot. |
| 1 | 12.25-inch muzzle-loading rifle shot. |
| 210 | 15-inch gun shot. |
| 1,000 | 1.5-inch revolving gun shell. |
| 872 | 1.65-inch mounting gun shell. |
| 200 | 3-inch rifle shell. |
| 1,513 | 3.2-inch rifle shell. |
| 595 | 4.5-inch shell. |

| | |
|---|---|
| 28 | 30-pounder Parrott shell. |
| 1 | 5-inch breech-loading rifle shell. |
| 1 | 7-inch breech-loading howitzer shell. |
| 100 | 8-inch converted rifle shell. |
| 170 | 8-inch muzzle-loading rifle shell. |
| 1 | 3.6-inch mortar shell. |
| 88 | 8-inch mortar shell. |
| 18 | 10-inch mortar shell. |
| 201 | 12-inch breech-loading mortar shell. |
| 1 | 12-inch muzzle-loading mortar shell. |
| 150 | 13-inch mortar shell. |
| 677 | 1.65-inch canister. |
| 495 | 1.65-inch case shot. |

## CLASS VI.

| | |
|---|---|
| 1,237 | Springfield carbines, caliber .45. |
| 3,106 | Springfield rifles, caliber .45. |
| 105 | Springfield rifles, rod bayonet, caliber .45. |
| 1 | Springfield rifle, cavalry and infantry, experimental. |
| 99 | Springfield shot guns. |
| 96 | Colt's revolvers, caliber .38. |
| 968 | Colt's revolvers, caliber .45. |
| 31 | Schofield-Smith and Wesson revolvers, caliber .45. |
| 96 | Smith and Wesson revolvers, caliber .38. |
| 1 | Chaffee-Reece magazine rifle. |
| 1 | Hotchkiss magazine rifle. |
| 1 | Lee magazine rifle. |
| 17 | light artillery sabers. |
| 180 | light cavalry sabers. |
| 54 | light cavalry sabers, foreign. |
| 73 | musicians' swords. |
| 39 | non-commissioned officers' swords. |
| 106 | hospital corps knives. |
| 968 | hunting knives. |

## CLASS VII.

### APPENDAGES.

| | |
|---|---|
| 12 | brushes and thongs. |
| 6 | cleaning rods. |
| 32 | drifts, caliber .38 revolvers. |
| 3,904 | headless shell extractors. |
| 8 | ratchet-sets. |
| 1,696 | combination screw-drivers. |
| 563 | revolver screw-drivers. |
| 153 | spring vises. |
| 557 | tumbler-punches. |
| 1,261 | carbine wiping rods. |
| 4,194 | rifle wiping rods. |
| 67 | revolver wiping rods, caliber .45. |
| 96 | revolver wiping brushes, caliber .38. |
| 96 | revolver wiping rods, caliber .38. |
| 8 | revolver wrenches, caliber .38. |

| | |
|---|---|
| 3, 100 | blank cartridges, 2½-pounds charge. |
| 3, 500 | blank cartridges, 3¾-pounds charge. |
| 3, 676 | blank cartridges, 6-pounder gun. |
| 17, 150 | blank cartridges, 12-pounder gun. |
| 1, 684 | blank cartridges, mountain howitzer. |
| 86 | combination fuses. |
| 805 | percussion fuses. |
| 501 | time fuses. |
| 238 | wood fuses. |
| 24, 700 | pounds cannon powder. |
| 13, 500 | pounds mammoth powder. |
| 25 | pounds mealed powder. |
| 13, 800 | pounds mortar powder. |
| 14, 420 | pounds oriental hexagonal powder. |
| 17, 540 | pounds sphero-hexagonal powder. |
| 3, 301 | electric primers. |
| 41 | electric obturating primers. |
| 150, 859 | friction primers. |

## CLASS IX.

| | |
|---|---|
| 14 | sets azimuth instruments, complete. |
| 7 | sets base measuring apparatus. |
| 3 | blocks, double. |
| 55 | blocks, half. |
| 51 | blocks, quarter. |
| 5 | blocks, single. |
| 5 | blocks, snatch. |
| 2 | blocks, triple. |
| 89 | blocks, whole. |
| 288 | blocks, wood, various sizes. |
| 1 | set bolsters and caps for gun lift. |
| 1 | set bolts and keys for gun lift. |
| 152 | bolts and nuts for mortar platform. |
| 1 | capstan barrel. |
| 11 | capstan holdfasts. |
| 1 | cap shears. |
| 20 | chocks, casemate. |
| 144 | chocks, gun. |
| 90 | chocks, roller. |
| 113 | chocks, wheel. |
| 3 | cradles. |
| 18 | cradle rollers. |
| 9 | cranes, loading. |
| 6 | floor boards, gun carriage. |
| 3 | gins, garrison. |
| 1 | gin, Piper's. |
| 3 | gin falls. |
| 7 | gin handspikes. |
| 6 | gin shoes. |
| 3 | gin slings. |
| 2 | hand barrows. |
| 1 | hand-cart. |
| 141 | halliards. |
| 30 | hat ornaments, cadet. |
| 8 | hydraulic jacks, lifting. |

| | |
|---|---|
| 257 | cross pieces. |
| 76 | frames, Brinton. |
| 38 | frames, Cushing. |
| 15 | frames, rolling. |
| 965 | frames, steel. |
| 831 | frames, wood. |
| 190 | journal boxes. |
| 365 | journal-box pins. |
| 26 | journal-box posts. |
| 938 | keys or wedges, wood. |
| 42 | levers. |
| 166 | lever blocks. |
| 2 | lock bolts. |
| 2 | lock-bolt plates. |
| 175 | nave boxes. |
| 6 | open links. |
| 12,959,000 | pasters. |
| 378 | pins, wood. |
| 1 | pulley. |
| 151 | rails. |
| 20,228 | silhouettes, cloth. |
| 103,818 | silhouettes, paper. |
| 4 | sills. |
| 8 | sill stakes. |
| 2 | spring loops. |
| 7,710 | strings. |
| 2 | swivels. |
| 361 | uprights. |

### RELOADING TOOLS, ETC.

| | |
|---|---|
| 5 | sets bench reloading tools, complete. |

### SHELL RESIZING TOOLS AND PARTS.

| | |
|---|---|
| 2 | shell resizing tools. |
| 2 | cartridge-head adjusting screws. |
| 6 | cartridge-head adjusting screw nuts. |
| 1 | disk. |
| 107 | dies, lower. |
| 101 | dies, upper, revolver. |
| 658 | dies, upper, rifle. |
| 2 | lever pins. |
| 2 | lever-pin screws. |
| 4 | links. |
| 10 | link pins. |
| 10 | link-pin screws. |
| 16 | rings. |
| 15 | spindles. |
| 2 | stands. |

### ASSEMBLING AND CRIMPING TOOLS AND PARTS.

| | |
|---|---|
| 1 | assembling and crimping tool. |
| 8 | check levers. |
| 7 | check-lever springs. |

| | |
|---|---|
| 3 | resizing dies. |
| 25 | drifts. |
| 22 | funnels. |
| 4 | oil cans. |
| 20 | priming tools. |
| 1 | resizing punch. |

### GALLERY-PRACTICE TOOLS.

| | |
|---|---|
| 8 | canisters. |
| 6 | ladles, melting. |
| 8 | ladles, pouring. |
| 4 | strainers. |

## Class X.

### PARTS OF CLASS I.

| | |
|---|---|
| 2 | axis pins, washers and nuts, Gatling guns. |
| 2 | binding boxes, plates, etc., Gatling gun. |
| 3 | bushings, obturator, spindle for 5-inch rifle. |
| 2 | cranks, handles, and pins, Gatling gun. |
| 1 | crank spring, Gatling gun. |
| 2 | pointing levers, Gatling gun. |
| 2 | brass trunnion rings, 10-inch, cast-iron wire-wound gun. |

### PARTS OF CLASS II.

| | |
|---|---|
| 58 | parts 8-inch carriage. |
| 36 | parts 10-inch carriage. |
| 57 | parts 15-inch carriage. |
| 2 | ammunition chests for limber. |
| 4 | ammunition chest lid braces. |
| 5 | ammunition-chest covers, canvas. |
| 48 | angle irons. |
| 1 | barbette carriage rail (I beam). |
| 2 | bow-spring brakes. |
| 6 | road brakes. |
| 2 | spring brakes. |
| 11 | double trees. |
| 1 | elevating screw. |
| 2 | limber primer box caps. |
| 12 | limber plates, corrugated. |
| 40 | linchpins. |
| 46 | linch washers. |
| 1 | lunette prop. |
| 13 | neck yokes. |
| 25 | poles. |
| 1 | pole iron. |
| 1 | pole pintle. |
| 16 | pole props. |
| 5 | pair shafts, Hotchkiss mountain gun. |
| 2 | side rails, caisson. |
| 19 | single trees. |
| 1 | stay pin and chain. |
| 1 | stock, 12-pounder gun carriage. |
| 2 | trunnion bushings, 12-inch breech-loading rifle gun carriage. |
| 12 | wheels. |

### PARTS OF CLASS III.

| | |
|---|---|
| 132 | back strap hooks. |
| 4 | breast straps. |
| 88 | breast-strap hooks. |
| 12 | breech sight-tubes, glass. |
| 4 | brow bands. |
| 116 | brass-plated buckles. |
| 99 | iron roller buckles. |
| 16 | collars, steel. |
| 12 | collar hinge nuts. |
| 36 | collar pads. |
| 32 | collar pads, steel. |
| 4 | collar snaps. |
| 6 | collar-snap screws. |
| 6 | collar-snap springs. |
| 36 | collar-spring catches. |
| 24 | collar-spring catch screws. |
| 132 | collar straps. |
| 132 | collar strap hooks and D-rings. |
| 12 | collar strap plates. |
| 5 | handspike spring clasps. |
| 9 | halter chains. |
| 100 | halter headstalls. |
| 16 | hame clasps, chains, and toggles. |
| 108 | hame screws. |
| 1 | martingale. |
| 6 | neck yokes. |
| 5 | pole pads. |
| 8 | pole straps. |
| 22 | rammer heads, 3-inch. |
| 428 | rings, new pattern harness. |
| 555 | saddle thongs. |
| 12 | snap hooks for coupling reins. |
| 14 | sponge heads, 3-inch. |
| 30 | sponge heads, 3.2-inch bore. |
| 24 | sponge head, 3.2-inch chamber. |
| 4 | sponge heads, 12-pounder gun. |
| 4 | sponge heads, mountain howitzer. |
| 3 | sponges, woolen, Hotchkiss mountain gun. |
| 18 | sponges, woolen, 6-pounder gun. |
| 119 | sponges, woolen, 12-pounder gun. |
| 162 | sponges, woolen, 3-inch gun. |
| 48 | sponges, woolen, 3.2-inch gun, bore. |
| 58 | sponges, woolen, 3.2-inch gun chamber. |
| 32 | sponges, woolen, 4.5-inch gun. |
| 6 | sponges, woolen, 8-inch gun. |
| 10 | sponges, woolen, 10-inch gun. |
| 47 | sponges, woolen, 15-inch gun. |
| 10 | stirrups, brass. |
| 21 | lead traces. |
| 15 | wheel traces. |
| 276 | trace chains. |
| 28 | pairs trace springs, Mogul. |
| 1 | trunnion saddle. |
| 151 | whips. |

### PARTS OF CLASS V.

| | |
|---|---|
| 250 | pounds 3.2-inch shrapnel balls. |
| 184 | 3.2-inch shell base plugs. |
| 200 | 5-inch shell copper bands. |
| 100 | 8-inch mortar shell fuse plugs. |
| 562 | 15-inch shell fuse plugs and water caps. |

### PARTS OF CLASS VI.

#### *Springfield carbine.*

| | |
|---|---|
| 93 | bands. |
| 1,184 | front sights. |
| 544 | front-sight covers. |
| 162 | front-sight cover pins. |
| 93 | front-sight cover screws. |
| 896 | front-sight pins. |
| 930 | jointed ramrods. |
| 719 | rear sights. |
| 84 | rear sight base screws. |
| 2,752 | sight protector bands. |
| 937 | stocks, wood part. |
| 43 | swivel bars. |
| 33 | swivel bar rings. |

#### *Springfield rifle.*

| | |
|---|---|
| 44 | lower bands. |
| 47 | upper bands. |
| 131 | band springs. |
| 8 | bayonets. |
| 21 | bayonet clasps. |
| 62 | bayonet-clasp screws. |
| 12 | bayonet-clasp stop screws. |
| 335 | breech-block cap screws. |
| 290 | bridles. |
| 409 | bridle screws. |
| 44 | butt plates. |
| 14 | butt-plate covers. |
| 119 | butt-plate screws. |
| 548 | cam-latch springs. |
| 14 | cover friction springs. |
| 6 | cover springs. |
| 10 | cover-spring screws. |
| 10 | cover stud pins. |
| 1,316 | ejector springs. |
| 1,193 | ejector-spring spindles. |
| 252 | ejector studs. |
| 1,899 | extractors. |
| 5,080 | firing pins. |
| 771 | firing-pin screws. |
| 419 | front sights. |
| 71 | front-sight covers. |
| 303 | front-sight cover screws. |
| 229 | front-sight pins. |

| | |
|---|---|
| 34 | guard bows. |
| 5 | guard-bows, swiveled. |
| 55 | guard-bow swivels. |
| 74 | guard-bow swivel screws. |
| 55 | guard-bow nuts. |
| 22 | guard plates. |
| 189 | guard screws. |
| 222 | grips. |
| 268 | grip screws. |
| 164 | hammers. |
| 386 | hinge pins. |
| 36 | hinge-pin studs. |
| 22 | locks. |
| 44 | lock plates. |
| 482 | mainsprings. |
| 273 | mainspring swivels. |
| 266 | mainspring swivel rivets. |
| 63 | ramrods. |
| 137 | ramrod stops. |
| 396 | rear sights. |
| 473 | rear-sight screws, front. |
| 467 | rear-sight screws, rear. |
| 1 | rod bayonet. |
| 40 | rod-bayonet heads. |
| 475 | sears. |
| 504 | sear screws. |
| 749 | sear springs. |
| 460 | sear-spring screws. |
| 327 | side screws. |
| 40 | side-screw washers. |
| 1,023 | stocks, wood part. |
| 15 | stocks, wood part, rod bayonet. |
| 286 | tang screws. |
| 59 | tips. |
| 60 | tip screws. |
| 115 | triggers. |
| 70 | trigger screws. |
| 624 | tumblers. |
| 631 | tumbler screws. |

### *Spingfield shotgun.*

| | |
|---|---|
| 14 | extractors. |
| 1 | front sight. |

### *Parker shotgun.*

| | |
|---|---|
| 12 | firing pins. |
| 6 | forehand screws. |
| 6 | trigger-plate screws. |
| 6 | trigger screws. |
| 6 | trigger springs. |
| 6 | trip springs. |
| 6 | tumbler screws. |

### *Lee magazine rifle.*

| | |
|---|---|
| 1 | magazine. |

### *Colt's revolver.*

| | |
|---|---|
| 36 | back straps. |
| 393 | back strap screws. |
| 1 | barrel. |
| 405 | bolts. |
| 289 | bolt screws. |
| 207 | center pins. |
| 155 | center-pin bushings. |
| 111 | center-pin screws. |
| 209 | center-pin catch screws. |
| 47 | cylinders. |
| 175 | ejector heads. |
| 182 | ejector rods. |
| 3 | ejector-rod heads. |
| 232 | ejector springs. |
| 68 | ejector tubes. |
| 161 | ejector-tube screws. |
| 51 | firing pins. |
| 45 | firing-pin rivets. |
| 11 | frames. |
| 21 | front sights. |
| 163 | gates. |
| 111 | gate catches. |
| 130 | gate-catch screws. |
| 195 | gate springs. |
| 29 | guards. |
| 216 | guard screws, long. |
| 227 | guard screws, short. |
| 774 | hammers. |
| 63 | hammer cams. |
| 41 | hammer rolls. |
| 36 | hammer-roll rivets. |
| 266 | hammer screws. |
| 395 | hands. |
| 305 | hand springs. |
| 224 | mainsprings. |
| 180 | mainspring screws. |
| 25 | recoil plates. |
| 93 | sears. |
| 12 | sear-spring screws. |
| 644 | sear and stop-bolt springs. |
| 383 | sear and stop-bolt spring screws. |
| 144 | stocks. |
| 453 | triggers. |
| 304 | trigger screws. |

### *Schofield-Smith and Wesson revolver.*

| | |
|---|---|
| 4 | extractors. |
| 4 | extractor springs. |
| 4 | extractor stems. |
| 4 | hammers. |

| | |
|---:|---|
| 8 | hands. |
| 10 | hand springs. |
| 10 | mainsprings. |
| 6 | triggers. |
| 44 | cavalry saber scabbards. |
| 6 | musician sword scabbards. |
| 4 | non-commissioned officers' sword scabbards. |
| 10 | scabbard mouth pieces. |

### PARTS OF CLASS VII.

| | |
|---:|---|
| 410 | bridle bits. |
| 36 | bridle ornaments. |
| 5,949 | brass bar buckles. |
| 4 | cincha buckles. |
| 1,292 | iron bar buckles. |
| 1,797 | iron roller buckles. |
| 3,007 | brass wire buckles. |
| 1,516 | canteen covers. |
| 722 | canteen corks and chains. |
| 20 | carbine-sling swivel springs. |
| 148 | cincha straps. |
| 11,112 | coat straps. |
| 32 | cruppers. |
| 60 | curb-bit bars, steel. |
| 585 | curb straps. |
| 10,214 | escutcheon pins. |
| 106 | girth straps. |
| 1,146 | guard plates (ovals). |
| 629 | halter bolts. |
| 36 | halter chains. |
| 555 | halter squares. |
| 138 | halter-swivel rings. |
| 24 | haversack-strap hooks |
| 1,436 | brass rings. |
| 306 | iron D-rings. |
| 1,425 | iron rings. |
| 40 | spur rowels. |
| 24 | saber-belt slides. |
| 509 | saber-belt snaps. |
| 793 | saber straps. |
| 60 | saddlebag straps. |
| 54 | saddlebag studs. |
| 390 | saddle nails, japanned. |
| 170 | saddle shields. |
| 170 | side-line fasteners. |
| 478 | snap-hooks, lariat. |
| 39 | spring snaps. |
| 973 | brass foot staples. |
| 1,728 | brass staples for rings. |
| 2,000 | waist-belt plate catchers. |

### PARTS OF CLASS VIII.

| | |
|---:|---|
| 1,280 | 6-pounder cartridge bags. |
| 2,747 | 12-pounder cartridge bags. |

| | |
|---|---|
| 100 | 30-pounder cartridge bags. |
| 1,550 | 3-inch cartridge bags. |
| 500 | 3.2-inch cartridge bags, blank charge. |
| 700 | 3.2-inch cartridge bags, service charge. |
| 2,933 | 4.5-inch cartridge bags. |
| 1,408 | 8-inch cartridge bags. |
| 200 | 10-inch cartridge bags. |
| 348 | 15-inch cartridge bags. |

## *PART SECOND.*

### CLOTH, ROPE, THREAD, ETC.

| | |
|---|---|
| 50 | yards burlaps. |
| 16,939 | yards cotton cloth. |
| 160 | pounds cotton waste. |
| 90 | pounds marline. |
| 715¾ | pounds hemp rope. |
| 4,790½ | pounds manila rope. |
| 9 | pieces sash cord. |
| 106¼ | pounds sash cord. |
| 95 | pounds linen thread. |
| 456½ | pounds shoe thread. |
| 52 | pounds twine. |
| 404 | yards blue linen webbing. |
| 5 | pounds spun yarn. |

### IRONMONGERY.

| | |
|---|---|
| 15 | anchors. |
| 932 | pounds anchors. |
| 309 | bolts. |
| 12 | bolts and nuts. |
| 25 | boundary posts, cast iron. |
| 1,724 | pounds chain. |
| 4 | fuse housings. |
| 15,025 | horseshoes. |
| 1,320 | pounds horseshoe nails. |
| 195 | pounds nails. |
| 1,477 | pounds bar iron. |
| 200 | pounds strap iron. |
| 197 | padlocks. |
| 127¼ | pounds brass rivets and burrs. |
| 378 | pounds copper rivets and burrs. |
| 66¾ | pounds iron rivets and burrs. |
| 16,150 | brass screws. |
| 2,592 | iron screws. |
| 100 | pounds spikes. |
| 411 | pounds steel. |
| 20,382 | copper tacks. |
| 44 | pounds copper tacks. |
| 1,777,038 | iron tacks. |
| 72⅝ | pounds iron tacks. |
| 60 | pounds toe calks. |

### LEATHER, ETC.

| | |
|---:|---|
| 41 | square feet bag leather. |
| 729½ | sides bridle leather. |
| 14,179 | pounds harness leather. |
| 208½ | pounds blackwax. |
| 113 | quarts leather blacking. |
| 76 | boxes ingredients for leather blacking. |
| 27 | ounces bristles. |
| 1 | side rawhide. |
| 25 | sheepskins with wool on. |

### LUMBER.

| | |
|---:|---|
| 1,120 | feet boards. |
| 520 | feet scantling. |
| 425 | feet timber. |

### CLEANING, HEATING, AND LIGHTING.

| | |
|---:|---|
| 34 | bath bricks. |
| 77 | corn brooms. |
| 3 | dusting brushes. |
| 2 | wire scratch brushes. |
| 83 | button brushes. |
| 80 | button sticks. |
| 28 | pounds candles. |
| 121 | chamois skins. |
| 13 | boxes cleaning material. |
| 7 | cleaning plates. |
| 10,340 | pounds coal. |
| 41 | quires crocus cloth. |
| 522½ | quires emery cloth. |
| 275 | quires emery paper. |
| 15 | gallons gasoline. |
| 19 | lanterns. |
| 76 | lantern globes. |
| 16¾ | pounds leather polish. |
| 10 | pounds hemp packing. |
| 46 | pounds Putz pomade. |
| 297½ | pounds rottenstone. |
| 78 | quires sandpaper. |
| 23¾ | pounds scouring material. |
| 1,721 | pounds castile soap. |
| 85 | pounds common soap. |
| 167 | pounds sponge. |
| 586 | papers tripoli. |
| 433 | ounces whiting. |

### MATERIAL FOR OFFICE USE.

| | |
|---:|---|
| 64 | instruction books. |
| 6 | bath trays. |
| 1 | box blacking for stencil outfit. |
| 1 | case for holding stamps. |
| 1 | chain scales. |

| | |
|---|---|
| 1 | compasses. |
| 6 | dividers. |
| 8 | drawing boards. |
| 8 | sets drawing instruments. |
| 7 | frames for blue printing. |
| 14 | magnifying glasses. |
| 2 | reading glasses. |
| 1 | bottle indelible ink. |
| 42 | bottles India ink. |
| 10 | bottles marking outfit ink. |
| 7 | sets colored ink. |
| 6 | boxes leads. |
| 13 | marking outfits. |
| 1 | marking outfit pad. |
| 1 | microscope. |
| 6 | pantographs. |
| 30 | rolls blue process paper. |
| 90 | yards cross-section paper. |
| 140 | yards drawing paper. |
| 22 | yards Levy's prepared paper. |
| 5 | boxes stencil paste. |
| 72 | crow-quill pens. |
| 84 | lithographing pens. |
| 72 | mapping pens. |
| 1 | gross steel pens. |
| 150 | lead-pencils. |
| 51 | protractors. |
| 12 | artists' rubbers. |
| 18 | elliptic rubbers. |
| 6 | sponge rubbers. |
| 13 | measuring rules. |
| 1 | parallel rule. |
| 12 | splines. |
| 36 | spline weights. |
| 12 | T squares. |
| 7 | seal stamps. |
| 1 | self-inking stamp, hand. |
| 3 | sets stamps, figures. |
| 34 | sets stamps, letters. |
| 21 | stencil outfits. |
| 6 | stencil plates. |
| 240 | thumb tacks. |
| 96 | yards tracing cloth. |
| 7 | pairs trestles. |
| 8 | triangles. |
| 13 | triangular scales. |
| 1 | unique steel blade. |

### LABORATORY STORES.

| | |
|---|---|
| 42 | gallons alcohol. |
| 6 | pounds aqua ammonia. |
| 2 | chemical balances. |
| 2 | air-drying baths. |
| 67½ | pounds beeswax. |
| 5 | pounds borax. |

| | |
|---|---|
| 20 | pounds camphor gum. |
| 5 | pounds chalk. |
| 1 | barrel rye flour. |
| 2 | brass spirit-lamps. |
| 1 | spatula. |
| 300 | pounds sulphate of copper. |
| ⅜ | pound tragacanth, gum. |
| 6 | thermometers. |
| 12 | sets watch glasses. |
| 1,686 | pounds Japan wax. |
| 2 | sets weights for balance. |
| 5 | gallons whisky. |

### OILS, PAINTS, ETC.

| | |
|---|---|
| 25 | quarts cosmolubric. |
| 130 | gallons coal tar. |
| 55⅞ | gallons Japan drier. |
| ⅞ | gallon liquid drier. |
| 10 | pounds glue. |
| 43¼ | gallons lacker. |
| 13 | pounds lampblack. |
| 275 | pounds white lead. |
| 7 | pounds extract logwood. |
| 5 | gallons castor oil. |
| 43½ | gallons cosmoline oil. |
| 3,164 | pounds harness oil. |
| 101½ | gallons kerosene oil. |
| 357½ | gallons boiled linseed oil. |
| 236⅝ | gallons raw linseed oil. |
| 30¾ | gallons lubricating oil. |
| 121½ | gallons neatsfoot oil. |
| 475 | gallons neutral oil. |
| 529½ | gallons sperm oil. |
| 905½ | pounds black paint. |
| 20 | pounds paint for 3.2-inch gun. |
| 75 | pounds paint for 3.2-inch gun carriage. |
| 315 | pounds lead-color paint. |
| 3,189½ | pounds metallic brown paint. |
| 1,948½ | pounds olive paint. |
| 200 | pounds oriental paint. |
| 4 | pounds red paint. |
| 10 | pounds vermilion paint. |
| 13 | pounds white paint. |
| 15 | pounds putty. |
| 10 | pounds tallow. |
| 331 | gallons turpentine. |

### MISCELLANEOUS.

| | |
|---|---|
| 17 | ammunition boxes. |
| 274 | arm chests. |
| 53 | carbine and revolver arm-racks. |
| 3 | revolver arm-racks. |
| 50 | rifle arm-racks. |
| 4 | tool bags. |

| | |
|---|---|
| 414 | powder barrels. |
| 1 | tool box. |
| 7 | chamois skin sword cases. |
| 1 | field case. |
| 2 | tool chests. |
| 50½ | pounds gutta percha. |
| 606 | pounds wheel-grease. |
| 6 | wheel-grease cans. |
| 6 | wheel-grease can knives. |

### INSPECTING INSTRUMENTS.

| | |
|---|---|
| 4 | arm calipers. |
| 3 | diameter calipers. |
| 3 | vernier calipers. |
| 1 | caliper rod. |
| 1 | caliper washer. |
| 1 | chamber gauge for mortar. |
| 1 | chamber gauge for rifle. |
| 1 | cylinder gauge. |
| 1 | gas check seat gauge. |
| 200 | pressure-gauge cylinders. |
| 500 | pressure-gauge checks. |
| 4 | sets measuring and fixed points. |
| 5 | ordnance stamps, steel. |
| 5 | standard rules. |
| 1 | star gauge. |
| 19 | star-gauge measuring points. |
| 28 | star-gauge measuring point washers. |
| 1 | star-gauge rifle guide. |
| 19 | ring gauges for setting star gauge. |
| 1 | conical rolling templet. |
| 15 | thickness gauges. |
| 2 | vent gauges, field. |
| 2 | vent gauges, siege. |

### MACHINES.

| | |
|---|---|
| 1 | drilling machine. |

### TOOLS.

| | |
|---|---|
| 7 | anvils. |
| 128 | aprons. |
| 1 | auger. |
| 2 | auger handles. |
| 713 | awls. |
| 206 | awl handles. |
| 13 | awl handles, patent. |
| 16 | axes. |
| 20 | ax handles. |
| 1 | coal bag. |
| 6 | bags for small stores. |
| 30 | bits. |
| 3 | braces. |
| 272 | brushes. |

| | |
|---|---|
| 16 | buckets. |
| 2 | buttresses. |
| 5 | calipers. |
| 2 | chains, surveyors', 100 feet. |
| 4 | chalk lines. |
| 34 | chisels. |
| 6 | clamps, stitching. |
| 21 | claw tools. |
| 7 | clinching irons. |
| 68 | compasses. |
| 20 | creasers. |
| 17 | dies. |
| 10 | die stocks and dies. |
| 3 | drifts. |
| 2 | dust pans. |
| 40 | edge tools. |
| 295 | files. |
| 40 | file handles. |
| 1 | fore punch and creaser. |
| 5 | fullers. |
| 19 | gauges. |
| 3 | gouges. |
| 5 | grindstones. |
| 1 | grindstone stand. |
| 174 | hammers. |
| 44 | hammer handles. |
| 18 | hardies. |
| 9 | hatchets. |
| 4 | jackscrews. |
| 222 | knives. |
| 4 | leveling rods. |
| 4 | levels, hand, Abney |
| 4 | levels, spirit. |
| 13 | mallets. |
| 2 | sets marking pins. |
| 11 | mauls. |
| 8 | collar needles. |
| 275 | glovers' needles. |
| 4,655 | harness needles. |
| 68 | nippers. |
| 14 | oil cans. |
| 2 | oil droppers. |
| 1,517 | oilstones. |
| 4 | oilers. |
| 1 | palm. |
| 8 | pickaxes. |
| 8 | pickax handles. |
| 45 | pincers. |
| 2 | planes. |
| 1 | plane iron. |
| 8 | pliers. |
| 2 | pokers. |
| 11 | pricking carriages and wheels. |
| 9 | pritchels. |
| 139 | punches. |
| 41 | spring punches. |

| | |
|---|---|
| 3 | spring-punch points. |
| 3 | punching blocks, lead. |
| 1 | rake. |
| 649 | rasps. |
| 15 | rivet sets. |
| 1 | riveting iron. |
| 20 | rules. |
| 7 | saddlers' horses. |
| 23 | sandstones. |
| 20 | sash tools. |
| 12 | saws. |
| 5 | saw blades. |
| 1 | saw-set. |
| 3 | scales and weights. |
| 1 | scales, platform. |
| 3 | scissors. |
| 6 | scrapers. |
| 14 | screw-drivers. |
| 25 | screw-drivers, gun-carriage. |
| 15 | screw taps. |
| 6 | scythes. |
| 2 | scythe snaths. |
| 1 | scythestone. |
| 23 | shears. |
| 5 | shoeing boxes. |
| 12 | shovels. |
| 5 | slickers, steel. |
| 30 | pairs magazine slippers. |
| 8 | spades. |
| 1 | spokeshave. |
| 5 | squares. |
| 1 | set stencil plates, figures. |
| 2 | sets stencil plates, letters. |
| 2 | strainers. |
| 2 | tape lines. |
| 2 | tapes, steel, 100-feet. |
| 2 | tap screws. |
| 19 | thimbles. |
| 30 | tongs. |
| 32 | vises. |
| 13 | wrenches, gun-carriage. |
| 25 | wrenches, screw. |
| 4 | wrenches, tap. |

# APPENDIX 4.

*Statement of ordnance, ordnance stores, etc., distributed to the militia from July 1, 1890, to June 30, 1891, under section 1661 and 1667, Revised Statutes United States.*

## CLASS I.

2 Gatling guns, 10 barrels, long, caliber, .45.

## CLASS II.

2 carriages and limbers (metallic) for Gatling guns, caliber .45.
1 carriage and limber (wood) for Gatling gun, caliber .45.

## CLASS III.

4 gunners' gimlets.
4 gunners' pincers.
2 gunners' punches.
4 handspikes, trail.
42 harness sacks.
10 lanyards.
8 priming wires.
2 prolonges.
4 pole pads.
2 paulins, 12 by 15 feet.
2 pendulum hausses..
2 pendulum hausse pouches.
12 sets artillery harness, two horses, lead.
12 sets artillery harness, two horses, wheel.
16 sponges and rammers, 3-inch gun.
16 sponges and rammers, 6-pounder gun.
8 sponges and rammers, combined, 3.2-inch breech-loading rifle.
8 sponge covers, chamber, 3.2-inch breech-loading rifle.
8 sponge covers, 6-pounder gun.
4 breech-site pouches.
8 thumbstalls.
4 tube pouches
2 tow-hooks.
2 tompions.
4 vent covers.
4 vent punches.
2 worms and staves.
8 whips, artillery.

### IMPLEMENTS FOR GATLING GUN.

| | |
|---|---|
| 12 | Accles feed magazines. |
| 2 | Bruce feed guides. |
| 2 | wiping rods. |
| 2 | cleaning rods. |
| 3 | pointing-lever set-screws. |
| 1 | crank-shaft split pin. |
| 1 | pin wrench. |
| 1 | lock screw-driver. |
| 1 | rear-sight collar. |
| 1 | rear-sight collar set-screw. |
| 1 | crank catch spring. |
| 2 | crank catch screws. |
| 2 | cocking switch pins. |
| 2 | cocking switch springs. |
| 2 | cocking switch stud screws. |
| 1 | extra lock. |
| 1 | brass padlock. |
| 1 | hammer, riveting. |

## CLASSES IV AND V.

| | |
|---|---|
| 10 | 10-inch shells. |
| 10 | 10-inch mortar shells. |
| 77 | 3-inch shot. |
| 100 | 3-inch Hotchkiss shells, time fuse. |
| 100 | 3.2-inch shells. |

## CLASS VI.

| | |
|---|---|
| 6,388 | Springfield rifles, model 1884. |
| 14 | Springfield cadet rifles, model 1884. |
| 280 | Springfield carbines, model 1884. |
| 50 | Colt's revolvers, caliber .45. |
| 82 | Schofield-Smith and Wesson revolvers, caliber .45. |
| 102 | officers' swords and cases. |
| 65 | sabers, cavalry officers, and cases. |
| 61 | sabers, light artillery. |
| 147 | sabers, light cavalry. |
| 21 | swords, non-commissioned officers'. |
| 10 | swords, musicians'. |
| 252 | bayonets. |

## CLASS VII.

### APPENDAGES.

| | |
|---|---|
| 8 | brush wipers and thongs. |
| 6,109 | headless shell extractors. |
| 225 | jointed ramrods. |
| 5,628 | screw-drivers, model 1879. |
| 6,479 | wooden wiping rods. |

### HORSE EQUIPMENTS.

| | |
|---|---|
| 467 | bridles, curb, cavalry. |
| 223 | bridles, watering. |
| 6 | bridle headstalls, cavalry. |
| 24 | pairs bridle reins. |
| 24 | curb bits. |
| 30 | curb straps. |
| 429 | saddles, leather-covered, cavalry. |
| 7 | saddle blankets, artillery. |
| 246 | saddle blankets, cavalry. |
| 331 | pairs spurs and straps. |
| 6 | pairs spurs and straps, officers. |
| 1 | saddle cloth, general officers. |
| 19 | saddle cloths, officers of infantry. |
| 1 | saddle cloth, officers of artillery. |
| 295 | halters, complete. |
| 153 | pairs saddlebags. |
| 100 | horse brushes. |
| 200 | nose-bags. |
| 100 | currycombs. |
| 104 | cruppers: |
| 100 | lariats. |
| 100 | picket pins. |
| 160 | links with snaps. |
| 100 | side-lines. |
| 100 | surcingles. |
| 3 | pairs sweat-leathers. |
| 24 | brass rings and staples for pommel and cantel of saddle. |
| 144 | brass screws for pommel and cantel of saddle. |

### INFANTRY EQUIPMENTS.

| | |
|---|---|
| 4,446 | bayonet scabbards. |
| 2,706 | blanket bags. |
| 1,106 | pairs blanket-bag shoulder straps. |
| 1,106 | pairs blanket-bag coat straps. |
| 3,231 | canteens and straps. |
| 2,631 | haversacks and straps. |
| 2,044 | cartridge belts and plates. |
| 200 | cartridge belts, 45 loops. |
| 100 | cartridge belts, 50 loops. |
| 3,827 | cartridge boxes. |
| 14,442 | gun slings. |
| 4,816 | waist belts and plates. |
| 200 | waist-belt plates. |
| 25 | waist belts and plates, non-commissioned officers'. |
| 25 | frogs, sliding, non-commissioned officers'. |
| 255 | officers' black leather sword belts. |
| 466 | meat cans. |
| 151 | tin cups. |
| 51 | knives. |
| 51 | forks. |
| 51 | spoons. |

### ARTILLERY ACCOUTERMENTS.

| | |
|---:|---|
| 111 | artillery saber belts and plates. |
| 25 | light artillery knapsacks. |

### CAVALRY EQUIPMENTS.

| | |
|---:|---|
| 250 | carbine slings and swivels. |
| 50 | cartridge belts, cavalry. |
| 170 | canteen straps, cavalry. |
| 40 | pistol holsters. |
| 310 | saber belts and plates. |
| 100 | snap-hooks for officers' sword belt. |

## Class VIII.

| | |
|---:|---|
| 500 | blank cartridges, 12-pounder gun. |
| 1,176 | blank cartridges, 6-pounder gun. |
| 4,800 | blank cartridges 3-inch rifle. |
| 400 | blank cartridges, 3.2-inch breech-loading rifle. |
| 1,779,040 | rifle ball cartridges, caliber .45. |
| 640,000 | rifle ball cartridges, caliber .50. |
| 54,000 | carbine ball cartridges, caliber .45. |
| 14,000 | rifle blank cartridges, caliber .50. |
| 461,120 | rifle and carbine blank cartridges, caliber .45. |
| 26,000 | revolver ball cartridges, caliber .45. |
| 14,800 | revolver blank cartridges, caliber .45. |
| 96,000 | lubricated rifle bullets, caliber .45. |
| 100,000 | round balls (140 grains), caliber .45. |
| 9,000 | carbine bullets, caliber .45. |
| 3,000 | primed cartridge shells (rifle), caliber .45. |
| 285,000 | cartridge primers. |
| 19,400 | friction primers. |
| 525 | fuses, time, paper. |
| 20 | cartridge-bags, 10-inch. |
| 20 | Bormann fuses. |
| 100 | base fuses, percussion, 3.2-inch shells. |
| 400 | pounds cannon powder. |
| 300 | pounds hexagonal powder. |
| 350 | pounds mortar powder. |
| 900 | pounds small-arms powder. |

### MISCELLANEOUS.

| | |
|---:|---|
| 338 | arm-chests. |
| 80 | boxes cleaning material. |
| 528 | marksman's buttons. |
| 4 | marksman's pins. |
| 209 | sharpshooters' badges. |
| 60 | silver bars for sharpshooters' badges. |
| 1,948,000 | pasters. |
| 7,725 | paper targets. |
| 47 | sets hand reloading tools. |
| 6 | sets bench reloading tools. |
| 50 | bullet molds (4 balls). |
| 2 | sets screws for bullet molds. |

| | |
|---|---|
| 2 | sand glasses. |
| 25 | pounds bullet lubricant. |
| 75 | yards cloth for targets. |
| 1,500 | centers for paper targets. |
| 1 | set marking rods, disks, and brushes. |
| 4 | sets shot marks and staves, short range. |
| 4 | sets shot marks and staves, mid range. |
| 3 | streamers with halliards. |
| 10 | arm racks, portable, for rifles. |
| 384 | steel frames for targets. |
| 1,011 | cloth silhouettes. |
| 6,450 | paper silhouettes. |
| 6 | Laidley revolving targets, 6 feet by 6 feet. |
| 6 | Laidley revolving targets, 6 feet by 12 feet. |
| 8 | Laidley target frames, 6 feet by 6 feet. |
| 1 | pair tool bags, cavalry. |

### PARTS SPRINGFIELD RIFLE, CALIBER .45.

| | |
|---|---|
| 263 | bridles. |
| 179 | bridle screws. |
| 30 | breech blocks. |
| 220 | breech-block caps. |
| 220 | breech-block cap screws. |
| 6 | butt plates. |
| 12 | butt-plate screws. |
| 90 | bayonet clasps. |
| 100 | bayonet-clasp screws. |
| 230 | cam latches. |
| 486 | cam-latch springs. |
| 1,236 | ejector springs. |
| 336 | ejector-spring spindles. |
| 2 | ejector studs. |
| 471 | extractors. |
| 241 | front sights. |
| 100 | front-sight covers. |
| 136 | front-sight pins. |
| 5 | front-sight rivets. |
| 50 | front-sight covers, spring. |
| 2,606 | firing pins. |
| 36 | firing-pin screws. |
| 58 | guard bows. |
| 80 | guard-bow nuts. |
| 95 | guard-bow swivels. |
| 425 | guard-bow swivel screws. |
| 32 | hammers. |
| 100 | hinge pins. |
| 182 | lower bands. |
| 16 | locks. |
| 10 | lock plates. |
| 157 | mainspring swivels. |
| 62 | mainspring swivel rivets. |
| 36 | leaf-slide binding screws. |
| 141 | rear sights. |
| 5 | rear-sight joint pins. |
| 10 | rear-sight base screws. |

| | |
|---|---|
| 5 | rear-sight base springs. |
| 82 | ramrods. |
| 100 | ramrod stops. |
| 3 | receivers. |
| 76 | rear-sight screws, front. |
| 76 | rear-sight screws, rear. |
| 400 | sears. |
| 410 | sear screws. |
| 36 | sear springs. |
| 36 | sear-spring screws. |
| 159 | side screws. |
| 403 | spring vises. |
| 215 | stocks, complete. |
| 6 | stocks (wood part). |
| 636 | tumblers. |
| 836 | tumbler screws. |
| 1,008 | tumbler punches. |
| 102 | tang screws. |
| 235 | thumb pieces. |
| 212 | upper bands, complete. |
| 36 | windage screws. |

### PARTS COLT'S REVOLVERS, CALIBER .45.

| | |
|---|---|
| 50 | firing pins. |
| 50 | firing-pin rivets. |
| 20 | hammers. |
| 25 | mainspring screws. |
| 100 | screw-drivers. |
| 50 | sear and bolt springs. |
| 25 | sear and bolt spring screws. |
| 50 | triggers. |

# APPENDIX 5.

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*Statement of ordnance, ordnance stores, etc., distributed to colleges from July 1, 1890, to June 30, 1891, under section 1225, Revised Statutes United States, as amended by act approved July 5, 1876.*

## CLASS I.

| | |
|---|---|
| 6 | 3-inch wrought-iron guns. |
| 1 | Gatling gun, caliber .45, with 2 Bruce feed guides. |
| 2 | 10-inch siege mortars. |

## CLASS II.

| | |
|---|---|
| 6 | 3-inch gun carriages and limbers. |
| 1 | Gatling gun carriage and limber, metallic. |
| 2 | 10-inch siege-mortar beds. |

## CLASS III.

| | |
|---|---|
| 11 | gunners' haversacks. |
| 1 | gunner's pouch. |
| 1 | gunner's quadrant. |
| 8 | handspikes, trail. |
| 4 | handspikes for mortars. |
| 1 | basket for mortar implements. |
| 1 | grommet wad. |
| 2 | pairs gunners' sleeves. |
| 12 | lanyards. |
| 3 | mauls. |
| 8 | priming wires. |
| 4 | paulines, 12 by 15 feet. |
| 2 | pendulum hausses. |
| 2 | pendulum hausse seats. |
| 2 | pendulum hausse pouches. |
| 1 | plummet. |
| 1 | pointing cord. |
| 1 | pointing stake. |
| 11 | sponges and rammers, 3-inch gun. |
| 8 | sponge covers, 3-inch. |
| 1 | scraper for mortar. |
| 1 | shell hook. |
| 12 | thumbstalls. |
| 5 | tompions. |
| 11 | tube pouches. |
| 6 | vent covers. |
| 3 | wipers for mortar. |
| 2 | wiper stakes. |

## CLASS VI.

| | |
|---|---|
| 1,056 | Springfield cadet rifles, model 1884. |
| 25 | Springfield carbines, model 1884. |
| 25 | sabers, cavalry. |
| 24 | swords, non-commissioned officers'. |
| 8 | swords, musicians'. |

## CLASS VII.

| | |
|---|---|
| 1,093 | headless shell extractors. |
| 1,081 | screw-drivers, model 1879. |
| 1,069 | bayonet scabbards, steel. |
| 1,021 | cartridge boxes, McKeever. |
| 1,039 | waist belts and plates. |
| 32 | waist belts and plates, non-commissioned officers'. |
| 22 | frogs, sliding, non-commissioned officers'. |
| 25 | saber belts and plates. |
| 25 | carbine slings and swivels. |
| 60 | pairs spur straps. |
| 1,081 | wooden wiping rods. |
| 1 | bullet mold (4 balls). |
| 25 | jointed ramrods. |

## CLASS VIII.

| | |
|---|---|
| 150 | blank cartridges, 12-pounder gun. |
| 300 | blank cartridges, 6-pounder gun. |
| 2,550 | blank cartridges, 3-inch gun. |
| 95,000 | carbine ball cartridges. |
| 49,000 | carbine blank cartridges. |
| 1,000 | rifle blank cartridges. |
| 1,000 | revolver ball cartridges. |
| 1,000 | revolver bullets. |
| 18,000 | carbine bullets (405 grains). |
| 38,000 | round balls (140 grains). |
| 1,000 | cartridge shells, primed, carbine. |
| 68,500 | cartridge primers. |
| 8,900 | friction primers. |
| 512 | pounds small-arms powder. |
| 2,000 | rifle ball cartridges. |

## CLASS IX.

| | |
|---|---|
| 1,200 | paper targets. |
| 130,000 | pasters. |
| 150 | centers for targets. |
| 1 | target for gallery practice, 100 feet range. |
| 1 | target for gallery practice, 75 feet range. |
| 3 | sets marking rods, disks, and brushes. |
| 4 | sets shot marks and staves, short range. |
| 2 | sets shot marks and staves, mid range. |
| 36 | paper silhouettes. |
| 7 | sets hand reloading tools. |

### MISCELLANEOUS.

68 arm chests.
2 chalk lines.

### PARTS SPRINGFIELD CADET RIFLE, MODEL 1884.

1 butt plate.
2 bridles.
2 bridle screws.
2 breech-block cap screws.
2 cam latch springs.
1 extractor.
5 ejector springs.
5 ejector spring spindles.
12 firing pins.
2 firing-pin screws.
1 mainspring.
6 stocks (wood part).
1 sear spring.
2 sear screws.
2 tumbler screws.
216 tumbler punches.
60 spring vises.

# Appendix 6.

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*Statement of ordnance stores issued to the Executive Departments during the year ended June 30, 1891, under the provisions of the act of March 3, 1879.*

## TO THE TREASURY DEPARTMENT.

| | |
|---:|---|
| 12 | Springfield rifles. |
| 18 | Colt's revolvers. |
| 24 | pistol holsters. |
| 12 | cartridge boxes. |
| 36 | waist belts and plates. |
| 1,000 | rifle ball cartridges. |
| 2,200 | revolver ball cartridges. |

# APPENDIX 7.

*Report of action taken under the act of March 3, 1881, during the fiscal year ended June 30, 1891.*

**NOTE.**—No purchases or sales have been made during the year.

# APPENDIX 8.

## *SHOWING STATIONS AND DUTIES OF THE OFFICERS OF THE ORDNANCE DEPARTMENT ON OCTOBER 1, 1891.*

| Rank and name. | Duty. | Address. |
|---|---|---|
| BRIGADIER-GENERAL. | | |
| D. W. Flagler | Chief of Ordnance | Washington, D. C. |
| COLONELS. | | |
| 1. J. M. Whittemore | On leave of absence. | |
| 2. A. R. Buffington | Commanding the National Armory, president of the Ordnance Board. | Springfield, Mass. |
| 3. A. Mordecai, brevet | Commanding the New York Arsenal, member of the Ordnance Board, president of Board for Testing Rifled Cannon, etc., and member of the Board of Ordnance and Fortification. | Governor's Island, New York City, P. O. box 1449. |
| LIEUTENANT-COLONELS. | | |
| 1. F. H. Parker, brevet | Commanding the Watervliet Arsenal | West Troy, N. Y. |
| 2. J. P. Farley | Inspector of pneumatic dynamite guns | Governor's Island, New York City, P. O. box 1449. |
| 3. L. S. Babbitt | Commanding the Benicia Arsenal | Benicia, Cal. |
| 4. W. A. Marye | Commanding Watertown Arsenal | Watertown, Mass. |
| MAJORS. | | |
| 1. I. Arnold, jr | Commanding the Columbia Arsenal | Columbia, Tenn. |
| 2. C. Comly | Commanding the Indianapolis Arsenal and representative of War Department U. S. Board of Management World's Columbian Exposition, Chicago, Ill. | Indianapolis, Ind. |
| 3. J. R. McGinness, brevet | Commanding the Fort Monroe Arsenal | Fort Monroe, Va. |
| 4. G. W. McKee, brevet | Commanding the Frankford Arsenal and member of Board on Magazine Arms and member of Board for Testing Rifled Cannon, etc. | Philadelphia, Pa. |
| 5. F. H. Phipps | Commanding the Allegheny Arsenal | Pittsburgh, Pa. |
| 6. J. W. Reilly | Commanding the United States Powder Depot. | Dover, N. J. |
| 7. J. A. Kress, brevet | Commanding the St. Louis Powder Depot | Jefferson Barracks, Mo. |
| 8. C. E. Dutton | Commanding the San Antonio Arsenal and chief ordnance officer Department of Texas. | San Antonio, Tex. |
| 9. J. G. Butler | Commanding the Augusta Arsenal | Augusta, Ga. |
| 10. C. Bryant | Commanding the Kennebec Arsenal | Augusta, Me. |
| CAPTAINS. | | |
| 1. A. L. Varney | On duty at Watertown Arsenal | Watertown, Mass. |
| 2. J. E. Greer | On inspection duty at the Builders' Iron Foundry, Providence, R. I. | 20 Market Square, Providence, R. I. |
| 3. J. Pitman | On inspection duty at West Point Foundry, Cold Spring, N. Y. | Cold Spring, N. Y. |
| 4. C. Shaler | Principal assistant in the Ordnance Bureau | Washington, D. C. |
| 5. H. Metcalfe | On leave of absence | |
| 6. C. S. Smith | On duty in the office of the Chief of Ordnance. | Do. |
| 7. S. E. Blunt | On duty at National Armory and member and recorder of the Board on Magazine Arms. | Springfield, Mass. |
| 8. F. Heath | Commanding the Sandy Hook Proving Ground and member of Board for Testing Rifled Cannon, etc. | Governor's Island, New York City, P. O. box 1449. |

## *SHOWING STATIONS AND DUTIES OF THE OFFICERS OF THE ORDNANCE DEPARTMENT ON OCTOBER 1, 1891*—Continued.

| Rank and name. | Duty. | Address. |
|---|---|---|
| CAPTAINS—continued. | | |
| 9. D. M. Taylor | On special duty in the office of the Adjutant-General, recorder of Board of Ordnance and Fortification and member of the Board for Testing Range and Position Finders. | Washington, D. C. |
| 10. D. A. Lyle | On inspection duty at the Midvale Steel Works, Nicetown, Philadelphia, Pa., and member of Board on Life-Saving Apparatus, etc., under the Secretary of the Treasury. | P. O. box 1606, Philadelphia, Pa. |
| 11. J. Rockwell, jr | On duty at Benicia Arsenal | Benicia, Cal. |
| 12. J. C. Ayers | Commanding the Omaha Ordnance Depot and chief ordnance officer Department of the Platte. | Omaha, Nebr. |
| 13. M. W. Lyon | On duty at Rock Island Arsenal | Rock Island, Ill. |
| 14. C. W. Whipple | In charge of ordnance exhibit, World's Columbian Exposition, Chicago, Ill. | Washington, D. C. |
| 15. A. H. Russell | On inspection duty at the South Boston Iron Works. | South Boston, Mass. |
| 16. R. Birnie | On duty in the office of the Chief of Ordnance. | Washington, D. C. |
| 17. I. MacNutt | On duty at Watervliet Arsenal | West Troy, N. Y. |
| 18. C. C. Morrison | do | Do. |
| 19. F. Baker | On duty at Frankford Arsenal | Philadelphia, Pa. |
| 20. O. B. Mitcham | On inspection duty at the Midvale Steel Works, Nicetown, Philadelphia, Pa. | P. O. box 1606, Philadelphia, Pa. |
| 21. H. D. Borup | Military attaché United States Legation, Paris. | Paris, France. |
| 22. L. L. Bruff | Instructor of ordnance and gunnery, United States Military Academy. | West Point, N. Y. |
| 23. C. H. Clark | Commanding the Vancouver Barracks Ordnance Depot and chief ordnance officer Department of the Columbia. | Vancouver Barracks, Wash. |
| 24. Wm. Crozier | On duty in the office of the Chief of Ordnance. | Washington, D. C. |
| 25. W. B. Gordon | On duty at Watervliet Arsenal | West Troy, N. Y. |
| FIRST LIEUTENANTS. | | |
| 1. F. E. Hobbs | On inspection duty at the Bethlehem Iron Works, South Bethlehem, Pa. | South Bethlehem, Pa. |
| 2. D. A. Howard | On duty at Watervliet Arsenal | West Troy, N. Y. |
| 3. S. E. Stuart | On inspection duty at the Bethlehem Iron Works, South Bethlehem, Pa. | South Bethlehem, Pa. |
| 4. J. W. Benét | On duty at Frankford Arsenal | Philadelphia, Pa. |
| 5. W. W. Gibson | On duty at Sandy Hook Proving Ground and member of Board for Testing Rifled Cannon, etc. | Governor's Island, New York City, P. O. box 1449. |
| 6. E. B. Babbitt | Assistant instructor of ordnance and gunnery, United States Military Academy. | West Point, N. Y. |
| 7. O. M. Lissak | On duty at Sandy Hook Proving Ground and member of Board for Testing Rifled Cannon, etc. | Governor's Island, New York City, P. O. box 1449. |
| 8. B. W. Dunn | On duty at Watertown Arsenal | Watertown, Mass. |
| 9. J. T. Thompson | On duty at Rock Island Arsenal | Rock Island, Ill. |
| 10. C. B. Wheeler | On duty at Sandy Hook Proving Ground | Governor's Island, New York City, P. O. box 1449. |
| 11. F. P. Peck | On duty at National Armory | Springfield, Mass. |
| ORDNANCE STOREKEEPERS. | | |
| *Captains.* | | |
| A. S. M. Morgan | On duty at Allegheny Arsenal | Pittsburgh, Pa. |
| W. H. Rexford | On duty at National Armory, with rank of major. | Springfield, Mass. |
| M. J. Grealish | On duty at Rock Island Arsenal | Rock Island, Ill. |
| V. McNally | On duty in the office of the Chief of Ordnance. | Washington, D. C. |

# APPENDIX 9.

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*REPORT OF THE PURCHASING OFFICERS OF THE ORDNANCE DEPARTMENT, SHOWING THAT SMALL PURCHASES CAN NOT BE MADE AS ADVANTAGEOUSLY BY ADVERTISING AS IF PERMITTED TO BE MADE IN OPEN MARKET, IN THE MANNER COMMON AMONG BUSINESS MEN.*

ORDNANCE OFFICE, WAR DEPARTMENT,
*Washington, D. C., October* 12, 1888.

SIR: The Chief of Ordnance has recommended that section 3709 of the Revised Statutes shall not apply to purchases of supplies of less value than $200, and he requests that you will make report based on your experience in making small purchases by the present method of advertising for proposals.

It has been stated that these small purchases can not be made as economically by the present method as by resort to open market purchase, and moreover that the responsible business houses which furnish acceptable materials in many cases refuse to make bids under advertisements for small orders, being unwilling to incur the trouble and the formality the present system requires, and that when induced by personal requests to send in proposals they are generally above the prices at which they offer to sell like supplies over their counters for cash.

He requests that you will give your experience in the matter and generally submit any evidence you possess or arguments you may have to offer as to why the open market purchase of small quantities of supplies would be more advantageous to the United States than by purchasing them under advertisement as now practiced.

Where it is practicable to give facts and figures, please do so.

He requests that you will please forward your reports on this subject with the least practicable delay.

It is proposed to submit these reports to Congress in asking the exemption of small purchases from the operation of existing laws.

Respectfully, your obedient servant,

WILLIAM CROZIER,
*Lieut., Ord. Dept., U. S. Army.*

The COMMANDING OFFICER.

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*Report on present methods of procuring supplies for the Ordnance Department (in reply to circular of Chief of Ordnance, dated October* 12, 1888).

FRANKFORD ARSENAL,
*Philadelphia, Pa., November* 5, 1888.

Under existing regulations supplies and materials for the Ordnance Department are purchased by two methods.

*First.* Upon formal written contracts made upon proposals received in reply to newspaper advertisement of thirty days. These contracts cover a fiscal year, or the unexpired portion of the same remaining at the time the appropriation acts are passed. These contracts are made to cover all the articles required for specific known work, and all articles that experience suggests may possibly be required for emergencies and possible work, and are for such quantities of each article as the Government may require, more or less, to be delivered at such time as they may be required during the year.

*Second.* By informal special contracts, under proposals invited by circular-letter advertisement of from ten to thirty days, for immediate delivery of articles the necessity for which was not foreseen when the annual contracts at the beginning of the year were made; usually for emergencies and unexpected work.

NOTE.—A third method called emergency purchases in open market is contemplated but not practiced. The objections to this method made by accounting officers in Washington, the difficulties thrown around it, and the delay of writing to the Chief of Ordnance to obtain permission, and then of issuing circular advertisements for proposals, are such that the second method is rarely less objectionable, no matter what the emergency.

*First method.*—Much has been accomplished in the way of simplifying and reducing the labor, difficulties, and evils of carrying out this method by receiving the bids on uniform, carefully prepared printed catalogues, containing instructions and explanations to bidders. Notwithstanding this, the labor involved in the method is still enormous. The variety of articles required in connection with manufactures, tools, machinery, building work, and repairs is great. There were 2,582 separate items on the catalogue at this arsenal this year; 96 proposals were received, and 75 contracts made (5 copies of each). Placing the average number of bids on each item at six (estimated), it made 16,492 bids to be considered.

The labor connected with this work, up to the completion of the contracts, required the services of, say, six clerks and foreman nearly three months.

### EVILS OF THE FIRST METHOD.

(1) Specifications for quality and other matters must be determined a long time before the articles are wanted. The work is great and must be deputed to subordinates. It can not receive the close scrutiny of an officer that is desirable. It is not like waiting till an article is required; having an officer see the necessity for it, see exactly what is wanted, and purchase accordingly. The specifications must be exact, uniform, and bidders must conform thereto exactly in order that bids may be even for comparison. The result is that articles not suitable are purchased and loss results. The magnitude of this evil can not be fully described, except at great length, but will be appreciated by business men without explanation. (This evil does not apply to the regular supplies for known work. It does apply to most of the miscellaneous articles for possible or probable work, and it covers probably 80 per cent. of the articles on the catalogue.)

(2) The papers, business, and clerical labor in connection with the system are so great, and so crowded into one period of the year, so as to be beyond the grasp and comprehension of the officer. It must be run by subordinates, on a system, and can not receive the scrutiny desirable. The result is a tendency to get the papers in such form that they will

pass the scrutiny of accounting officers, and to lose sight of purchasing to the advantage of the Government and the work, which should be the prime object. This evil is not slight.

(3) This system is practically what is known as "gambling in futures" on many articles. The market prices will fluctuate during the year. The dealer knows this, and unless he is so venturesome as to be unsafe, in order to insure himself, he must make a price higher than the probable average price, and the Government loses. If the price goes up he sometimes accepts the loss quietly, but more often accepts it as Government oppression. Supplies are obtained with vexatious delays and, if he can effect it, below standard of quality, and the Government reaps part or all the loss. If the price goes down the dealer reaps all the profit.

(4) Many tools, machines, and many other articles are patented, or for other reasons can be furnished by one person only. This is known; bids are useless, and, to the public, foolishness. This brings contempt on the method and on the officer who employs it. This can be borne, but its tendency is to deter the best dealers from bidding, and to lead others to feel that the officer is not a shrewd business man, and to try to take advantage of him in dealings.

(5) Notwithstanding the efforts to simplify the business of the system to bidders through the catalogues mentioned, and in other ways, it is still complex. The contracts (5 copies) and their forms, bonds, and requirements are formidable to them.

Often important firms have their fixed system of doing business, which can not be made to conform. The amount of business is small and the formalities great. These objections, but especially the evils described under 3, and some of those under 1 and 4, deter the best dealers from bidding, and deprive the Government of an important advantage and privilege. At Rock Island I felt this, and could cite cases. Here I have not much acquaintance, except with those who do bid and enter into contract, and can not cite cases, but know the objection described exists. It not only causes loss, but involves a worse evil. Its tendency is to relegate the furnishing of Government supplies to "dealers in Government supplies." Some of these are fair dealers and some are not. It is not too harsh to say that some of them constitute a "ring," and speculate on these supplies. They are acquainted with all Government methods, give low bids, and make it uncomfortable for the officer if he rejects them. They force upon him as poor and cheap an article as possible, know his necessities, that his work will not admit of the delay of rejection and going into open market to purchase (often to have articles manufactured); endeavor to come in contact with foremen and inspectors, and to further their own interests at the expense of the Government.

*General remark.*—The principal evils are those described, or resulting from what has been stated under 1, 2, 4, and 5. These would, in my judgment, be almost entirely removed by the plan proposed by the Chief of Ordnance in his circular letter of October 12—that of permitting the purchase in open market of articles costing less than $200 when the interests of the Government demanded it.

### EVILS OF THE SECOND METHOD.

(6) Under the second method some of the above difficulties are removed, and others come in. Generally the article is required immediately. Under the system it requires from fifteen to forty days to go

through all the required forms and procure it. In the meantime work is delayed and loss incurred.

(7) This method is often an expensive one. I append hereto a sample lot of papers required for such a purchase. The estimated cost of stationery, postage, and clerical labor, and other expenses for getting ready to make such a purchase is as follows:

| For issuing circular advertisement to ten bidders: | |
|---|---|
| Clerical labor | $3.25 |
| Superintendent | .50 |
| Stationery—25 circulars, 25 envelopes (large), 2 abstracts, 4 letters | .25 |
| Postage | .60 |
| Total | 4.60 |

The total money amount of the last forty-one purchases made under this system was $1,478, making the expense of carrying out the system, say, 13 per cent. of the cost of the articles purchased. In more than half the cases the cost of the article was less than the cost of preparing these papers, and in many cases less than one-fourth the cost of preparing the papers.

(8) When circulars are issued, specifications as to quality, quantity, weight, dimensions, etc., are fixed by the knowledge at hand, and they must be fixed that bids may be comparable. The bids when received are often fruitful sources of better knowledge. They show that some other unknown, perhaps new and cheaper, article would be better; that a slight departure from specifications would give a better article, would admit many desirable bidders that are excluded, etc. But the regulations will not permit this without the delay of getting new authority to issue new bids, and the work can not wait.

I think of two cases which illustrate the principle of this last evil, though not its magnitude. I had lately to purchase a small lot of asbestus for covering pipes. The "Chalmers Spence" was the best known variety, and was specified. A bidder brought a new article, which for the peculiar special case would have been quite as good, at one-fourth the cost. It could not be accepted. I have at Rock Island called for bids for first clear pine for interior finishing, which is the proper and usually the cheapest lumber for such work. The bids developed the fact that the lumber was not in market and could be obtained only by transporting it from Chicago, and the bids were at high prices accordingly. At these high prices it would have been much better to purchase second clear and incur the labor and waste of cutting out bad parts; but the work could not wait another thirty days.

As stated, these cases illustrate the principle of the evil only.

### GENERAL REMARKS ON BOTH METHODS OF MAKING PURCHASES.

However great the care exercised in preparing the catalogue and specifications for bidders, numerous cases arise where important articles required during the year are not on the contracts. It is important for economy and success that they be purchased. The difficulties, and especially the delays, incident to a purchase by the second method are such that it must be avoided if possible. Shift is then made to get along by one of the following methods:

(*a*) To use in lieu of the proper article something that is on the contracts, often a more costly article than the one desired, and not suitable.

(*b*) To improvise or manufacture expensively something that can be made to answer.

(c) To get along without any article at all.

All these methods involve loss, and sometimes serious loss.

Under No. 4, above, the difficulties or objections to the purchase by advertisement of patented articles, or articles on which there can be no competition, was alluded to briefly. In addition to these there are a large class of other articles which can not be purchased reasonably or sensibly, under the competition of bids. Among them are such articles as gas fixtures, mantels, grates, some articles of house hardware, many tools, shop fixtures, some machines, many chemicals, furniture, etc. The only practicable method is to go into market as any other buyer would, select what is cheapest and best for the purpose, get the lowest prices possible, and then, for a compliance with regulations, call for formal written bids on the one article selected, with the certain knowledge that no bid can fill requirements and be accepted except the one from the dealer who has the selected article. This is certainly irregular and highly unsatisfactory, but it is the only practicable method. It is unfair to dealers.

During the year improvements and new articles come into use, and especially come to the knowledge of the officer, that were not known when the annual bids were prepared. They are cheaper and better than those on the contracts. The officer can not avail himself of them, to save cost and give better work, because of the delays and difficulties of purchasing under the second method, and because the contractor claims the right to furnish his contracted article. This tends to cast odium on Government work, and on the officer in charge of it. They both receive the epithet of "old fogy."

Among necessary articles which can not be purchased at all under the present system I will specify one, which I wish to purchase at the present time. I am satisfied from experience that several of the foreign steels now used in expensive machine tools at this arsenal and in reloading tools issued to the Army do not give as good results as might be obtained from some cheaper American steels. Some small experiments have proved that this is true. Before introducing this steel it is necessary first to obtain samples and make experiments; conference with the manufacturer is necessary. He must be shown the tool and the work it is to perform. He then furnishes a steel he deems best adapted to that one purpose. It is tried, results reported, and new trials made on another quality, and so on until a steel exactly adapted to the work is obtained. This must be done for many varieties of tools. All tool-steel users are familiar with this. It is of the highest importance for economical and successful work. To carry it out numerous samples must be purchased; they can not be purchased under bids and contracts. The method employed then is to explain the matter to the steel manufacturer, induce him to furnish the samples with the understanding that if the steel succeeds a contract will be made with him next year, and he can then be paid for the samples. This is irregular and unsatisfactory. If it fails, I am personally responsible for the steel, must pay for it out of my own pocket, and then try another manufacturer. After the best steel for a particular work is found, grades established, and workmen have learned how to treat it, competitive bids are foolishness. Only that one steel can be used until another series of experiments have established a better.

Another case in point at the present time is the purchase of horses. I am compelled to purchase a draught horse. Bids for the same were asked for, and the qualities of the horse were specified with great care. Two bids were received, one at $300, one at $249.50, and the latter accepted and a contract made. The contract simply destroyed all competition, and that was its only effect. The object sought now is to get as good a horse from one dealer—the contractor—as I can for the money. The only hold I have on him is that if he will not furnish a satisfactory horse I will buy none at all, and he loses the profit on a valuable bargain. If he concludes I must have the horse, this is no hold at all. With the contract I have no competition; without it I would have the competition of all dealers. I believe I could go among farmers and buy a better horse for $200 than I can get from the speculator for $249.50.

In answer to the specific question asked in the circular letter of the Chief of Ordnance, as the result of a long and tedious investigation, I have to state as follows:

*First.* Do dealers decline to bid because of the difficulties and formalities attending such bids and furnishing such supplies?—Answer. Yes. In consequence of these difficulties under both methods of purchase, but especially under the second method, and also in consequence of the other objectionable features of the methods which I have described in this report, many of the best dealers, from whom it would be desirable to make small purchases, do not respond when called upon to make bids, and the Department can not, therefore, under the system now employed, make purchases from them. Out of 2,239 circular bids sent out requesting dealers to enter prices thereon and return them, only 373 were returned. (This takes into account items when there were several items in one bid.)

*Second.* Do the difficulties described cause dealers to enter higher prices on circular bids than they would charge for cash sales, and thus enhance prices of Government purchases?—Answer. No; they do not, except in rare cases. A full investigation shows as follows: A majority of dealers on receiving the circulars do not care—for reasons stated—to answer. If they do answer they enter their regular prices, not much expecting their acceptance, and are indifferent. In an open market purchase their desire to obtain and retain Government business would have caused them in many cases to discount these prices. On going into market and investigating I have found only about four articles in one hundred that I think would have been bought at lower prices in open market than the prices paid.

The business then falls into the hands of the few and they struggle to retain it; they, knowing or supposing they are in competition with those who will bid low on very poor articles, enter the lowest prices they can afford, and when all competition is ended by the acceptance of their bid and a contract they furnish as poor an article as they can get accepted, as explained under 5 in a previous part of this report. The effect of the system is rarely to enhance prices, but generally to reduce them and obtain articles of inferior quality, very expensive in the end. This answer applies mainly to the numerous small articles for possible or probable work on the annual contracts, and to purchases by the second method. It has only slight application to the larger purchases on the annual contracts.

In regard to the method proposed in your letter of purchasing in open market articles that cost less than $200, I have to state, after careful investigation, that in my judgment it would overcome and remove fully 80 per cent. of the evils of the present system described in this report. It would remove from the annual catalogue bids all the miscellaneous small articles for "possible" but "improbable" work, and reduce the catalogue to such size that the business could be managed intelligently and thoroughly. It would nearly remove all evils of the present system described under 1, 2, 5, 6, 7, and 8 in this report, and lessen those under 4.

Even if the privilege proposed is granted I know that small articles could often be purchased most economically by issuing circulars asking for prices, and when this is the case it should be done, and I believe it would be. I would state that before this system was adopted, whenever important purchases made by me could be made as advantageously through newspaper advertisement and formal contract as without, it was always done. Of other purchases I think quite 95 per cent. (money cost) were made by issuing circulars asking for prices. The advantage of that system was that my hands were not tied. I could watch markets and purchase at favorable opportunities, accept valuable offers of lots, go into market and ascertain exactly what was best suited for the work, get verbal offers, get prices by telegraph and circular letters, and in all cases do all that could be done in the interest of economy for the Government. The proposed change would again permit this to a less extent. Whenever the use of circular advertisements could be used to advantage they would be employed, whether required or not.

Respectfully submitted.

D. W. FLAGLER,
*Lieut. Col., Ord. Dept., Commanding.*

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ROCK ISLAND ARSENAL,
*Rock Island, Ill., October* 25, 1888.

SIR: In reply to your circular letter of October 12, 1888, in reference to the present system of making small purchases by advertising for proposals, I have the honor to report that it has frequently occurred here, in sending out proposals for small quantities of supplies involving small sums, that very few persons to whom the proposals were sent would respond at all. The reasons for this action on the part of dealers are set forth in the accompanying letters from Messrs. Sickels, Preston & Co., and Messrs. Reynolds & Gifford. The same reasons doubtless actuated other parties in declining to answer proposals sent to them from time to time, and at times when bids were received I have had to reject them all, when I knew them to be above the market price, and advertise again, thus involving considerable delay in procuring supplies.

Very respectfully, your obedient servant,

T. G. BAYLOR,
*Col., Ord. Dept., Commanding.*

The CHIEF OF ORDNANCE, U. S. A.,
*Washington, D. C.*

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DAVENPORT, IOWA, *October* 24, 1888.

DEAR SIR: In answer to your letter of the 20th instant, will say that you state our reasons for refusing bids for small orders, namely, we are unwilling to incur the trouble and formality the system requires.

Yours, respectfully,

REYNOLDS & GIFFORD.

Col. T. G. BAYLOR,
*Commanding Rock Island Arsenal, Rock Island, Ill.*

DAVENPORT, IOWA, *October* 23, 1888.

DEAR SIR: In reply to your valued favor of the 20th instant, it is true that we have declined to quote prices on your advertisements by circular for small purchases of hardware, as we can not afford to expose our prices, go through so much form and trouble, for so small amounts. If there is anything that you want for the Government we will name you our regular prices on same, which would of necessity be very much lower than the prices we would think of making that were to be advertised by open bids to all of our local competitors. The system adopted by the Government for the purchase of goods, in our opinion, is thoroughly wrong, expensive, and must of necessity cost the Government a great deal more for their supplies than it would if they would conform to the prescribed customs of commerce in their purchases.

Yours, respectfully,

SICKELS, PRESTON & CO.

Col. T. G. BAYLOR,
*Rock Island Arsenal, Rock Island, Ill.*

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NEW YORK ARSENAL,
GOVERNOR'S ISLAND, NEW YORK HARBOR,
*New York City, October* 19, 1888.

SIR: In reply to your letter of the 12th instant, in reference to the disadvantages attending the present method of making small purchases by advertising for proposals, I have the honor to submit the following remarks:

The objections to this system arise from the amount of clerical work necessary and the aversion shown by business men to dealing with any one using such methods as the Government requires. At an ordnance establishment where many purchases are made there is needed an additional clerk over and above the force necessary if the present system were not in use; so in the beginning the cost of purchases is increased.

The reluctance felt by business men causes, in many cases, those with whom the Government might deal to advantage to refuse utterly to submit prices; they are unwilling to be "annoyed," as they term it, with such peculiar methods, and as a result middle parties—"agents," or those not regular dealers—are the only ones from whom bids for some articles can be obtained. From this results an increase in the price of the wares above that at which they can be obtained from manufacturers, or from wholesale and regular dealers. Within the past month three firms have positively refused to be so "bothered" and submit proposals for furnishing their goods; thus three stoves required at this arsenal, though twice advertised for, have not been procured, because no bids for them could be obtained.

The following are the lowest bids once received for certain articles and their "open market" value, viz:

| Articles. | Bid. | Open market. |
|---|---|---|
| | *Cents.* | *Cents.* |
| Battery fluid | 10 | 5 |
| Cotton waste | 13 | 9 |
| Brass wire | 24 | 16 |
| Brass, sheet | 21 | 14 |
| Lead pipe | 8 | 5.4 |
| Iron, bar | 4.5 | 2.8 |
| Iron, bar | 6 | 3 |
| Iron, nails | 3.5 | 2.75 |

In a large city like New York the independence of the manufacturers and large dealers is more marked than in smaller places, and the bidders for supplies are to a great extent a class of men who style themselves "furnishers of Government supplies." They keep nothing in in stock, but buy wherever they can obtain the best "discount," and furnish articles of which they really know nothing, and which they have never seen.

In my judgment it should be possible for the Government always to obtain its supplies from the largest and best "businesss houses," and now this class of men in many cases refuse to deal with the Government.

Very respectfully, your obedient servant,

A. MORDECAI,
*Lieut. Col., Ord. Dept., U. S. Army, Commanding.*

The CHIEF OF ORDNANCE, U. S. A.,
*Washington, D. C.*

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NATIONAL ARMORY,
*Springfield, Mass., November 6, 1888.*

SIR: In accordance with the instructions of the circular letter of October 12 ultimo, relative to small purchases of less than $200 by the present method of advertising for proposals, I have the honor to submit the following:

(1) In the matter of actual price paid for articles so purchased there is little to be said. To buy in open market should not involve increased price. All that can be claimed for the present system, viz, competition, can be equally secured in open market purchases, without loss of time, etc., as detailed below, and the purchase of the right material—material up to the market standard—very much facilitated. Only those who make and have such for sale need then be asked to quote prices before purchase. Advertisement best opens a way for proposals from irresponsible dealers and agents whose material can not be accepted. The following items have during the past three months been purchased under the present system of advertising, that is, purchased under advertisement of ten days for a single and immediate delivery. These few will serve to illustrate this part of the subject, prices paid and prices at which they could have been bought in open market being stated opposite each:

| Name of bidder and article. | Cost accepted bid. | Cost in open market. |
|---|---|---|
| Kirkham & Estabrook, Springfield, Mass., one 22-inch tin folder | $35.00 | $35.00 |
| C. B. Arsino, Springfield, Mass., fifty zincs for batteries | 3.50 | 2.50 |
| J. F. Cranston, Springfield, Mass., two coal-oil lanterns | 1.92 | 1.92 |
| L. H. Mayott, Springfield, Mass., one paper-shell crimper; No. 12 | .65 | .65 |
| Homer Foot & Co., Springfield, Mass: | | |
| One hundred pounds hemp rope, ¾-inch | 12.50 | 12.50 |
| One wiring machine | 12.00 | *12.50 |
| Phillips Manufacturing Company, Springfield, Mass., one No. 4 swing stock, with cutter, dies, etc | 21.00 | 21.00 |
| George A. Graves & Sons, Springfield, Mass., forty dozen Grobet files | 73.20 | 74.70 |

* This increase the dealers explain would arise if they knew there was no competition. The same would obtain with any special articles—articles not usually kept in stock or in any quantity.

(2) Small purchases—small in amount, but often large in importance in connection with the public interest—are often necessary by reason of unexpected orders. These no amount of forethought can anticipate, and to make them under the law ten days at least must be lost, and in the majority of cases more, as follows: Twenty days are allowed in which to deliver; this time in many cases is not sufficient, and contract must be entered into—not sufficient for various reasons; deliveries are made, which, on account of quality, must be rejected, consuming time to replace them, or bids, contrary to strict injunctions, are made for articles not in possession, which must be procured by purchase elsewhere or by manufacture, and thus in one way or another the twenty days are consumed and still more time when contract must be entered into.

(3) In addition to these unexpected orders requiring purchases, whether from indisposition to bid or failure to observe the call for proposals, there are always a number of items of small amount for a single and immediate delivery in the yearly catalogue of supplies for which no bids are received, and which must be procured afterwards by circular advertisement and request of the armory to dealers to bid, increasing the loss of time, further embarrassing manufacture or issue, and, besides the detriment to the public interests, increasing the cost by additional clerical labor. One case occurring this year will serve to illustrate this. The yearly catalogue of supplies, bids to furnish which were called for by advertisement May 25, in prominent papers of Boston, New York, Philadelphia, and Springfield, contained the item of 40 gallons of neatsfoot oil, value of about $24. The lowest bidder for this item was a firm of Cleveland, Ohio, through an agent in Washington City.

As the requirements for the oil were fully stated in the catalogue, and no just grounds existing for rejecting the bid, it was accepted, it being but 1 cent less than the bid of a responsible firm that it was known could furnish what was needed, Delivery was made September 1, freight not prepaid as required. The oil being inferior, it was rejected and the firm notified September 3, to which no response was made. October 3 the company was again notified, but without response until the 10th, through a watchman of the armory, whom it had made a local agent. It has taken from August 11, when the order was given for the oil, to the 10th of October to procure, under an advertisement of thirty days, a barrel of neatsfoot oil and to find out that the successful bidder for it could not or would not supply it; this with all its attendent correspondence, etc., when the oil needed could have been bought in a few hours in Springfield, Mass., for a trifle more a gallon. After all this loss of time and expense the armory finds its need still unsupplied and the oil must be readvertised for to comply with the existing law.

(4) Articles of small value are often to be had only of one man or firm and at one price, and for which there can be no competition. The absurdity is therefore presented of advertising for what only one man or firm can supply, wasting often needful time and putting the supplier to the inconvenience and annoyance of going through with, in such cases, the useless formality of bidding; this, too, often for small amounts. For example, there have been recently made by circular advertisement of ten days, purchases of amounts following from—

| | |
|---|---|
| The Colt's Patent Fire-Arms Manufacturing Company | $1.72 |
| Winchester Repeating Fire-Arms Company | 3.00 |

(5) As above stated, no increase of cost need attend purchases of small amounts if dealers be invited to quote prices before placing

orders. The same proposals can be obtained as now under existing law without loss of time—at least of the ten days before the opening of bids—and with much less clerical labor.

Respectfully, your obedient servant,

A. R. BUFFINGTON,
*Lieut. Col., Ord. Dept., Commanding.*

The CHIEF OF ORDNANCE, U. S. A.,
*Washington, D. C.*

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WATERTOWN ARSENAL,
*Watertown, Mass., October* 30, 1888.

SIR: In answer to Ordnance Office letter of the 12th instant, I have the honor to submit the following remarks upon the effects of the present method of advertising for proposals when making small purchases at this arsenal:

Section 3709 of the Revised Statutes directs that "All purchases and contracts for supplies or services in any of the departments of the Government, except for personal services, shall be made by advertising a sufficient time previously for proposals respecting the same when the public exigencies do not require the immediate delivery of the articles or performance of the service. When immediate delivery or performance is required by the public exigency the articles or service required may be procured by open-market purchase or contract at the places and in the manner in which such articles are usually bought and sold or such services engaged between individuals."

This section has been interpreted to apply to everything that is purchased by the Ordnance Department except personal services.

If an exception could be made to the provisions of this general law allowing small purchases to be made without advertising for proposals, in cases where the amount of the purchase does not exceed $200, it would be a great relief at this arsenal, and it would, it is thought, be an economical measure to the Government. The principal supplies needed for the year are known and can generally be provided for by advertisement. But there are many articles, such as special tools, instruments, fixtures, small amounts of material, which can not be foreseen as needed, but which, when occasion requires, at a manufacturing and supplying establishment, are needed without delay in order to continue work to advantage, to which this method of advertising for the lowest bid is particularly inapplicable, as causing vexatious delay and extra expense. The time required under the present system in such cases to procure the article is from twelve to thirty-five days. It would, then, seem wiser to extend the exceptions to include such cases as these and allow small purchases to be made with celerity and economy.

As regards the comparative economy of the two methods, the proposed method of making small purchases in open market is certainly a saving of the expense of clerks in making out advertisements, blank proposals, abstracts of bids, the printing, and all the formal papers in as great number as if the purchase amounted to a great sum, and this expense in the aggregate amounts to no inconsiderable sum in the course of a year. If the purchase by advertisement is at the lowest market rates, it is evident that the stores have still cost the Government more than they would have if an open-market purchase had been made. But are they really always bought at the lowest market rates?

It is believed that they are not, but where the amounts involved are quite small the better class of dealers do not care to go through the formality of bidding, the amount of profit not paying them for the time and trouble required. The following is one instance:

In November, 1886, I advertised for 1,000 copper strips for projective bands. Only one bid was received in answer, at 35 cents per pound, which I was obliged to reject, as I had received an offer from the Revere Copper Company to sell the strips in open market for 20 cents per pound. December 17 I advertised again, and particularly solicited a bid from the Revere Copper Company, who sent in one at 30 cents—50 per cent higher than I could buy in open market of the same parties. This had to be accepted or go without. The amount of this purchase was only $137.70. In this case the successful bidder positively refused for a long time to have anything to do with bidding, but finally, when induced to bid, they made the Government pay well for the inconvenience occasioned them.

In March, 1887, a small quantity of steel plate for the fabrication of a 5-inch siege carriage was required. No bid received. Advertised again April 15; only one bid received for one item. May 3 advertised again, and upon repeated solicitations one firm bid to help us out of our difficulty, and after long delay we were enabled to go on with the work of constructing the carriage. The amount of this purchase slightly exceeded $200.

In 1886 Messrs. Austin & Fellows refused to make a contract for one item, which alone had been awarded them as the lowest bidder, although they would have been glad to sell over their counter the articles, which amounted to less than $200.

The above are only a few typical cases where a rigorous application of the advertising system to small purchases occasioned delay, embarrassment, and extra cost.

Of the 298 items advertised for at this arsenal during the fiscal year ending June 30, 1888, about 260 would have cost less than $200.

Of the 282 items for the year ending June 30, 1889, about 250 will be under $200. If these 510 items could have been purchased in open market there is no doubt that money would have been saved to the Government.

I therefore advise and recommend that, if possible, the law be so changed as to exempt from its provisions small purchases amounting to $200 and less, permitting them to be made in open market; but that in all cases where open-market purchases are made that the purchasing officer be required to certify that he has made careful inquiry of all dealers in the vicinity, and that the purchase is made at the lowest market rate.

Very respectfully, your obedient servant,

F. H. PARKER,
*Lieut. Col., Ord. Dept., U. S. Army, Commanding.*

THE CHIEF OF ORDNANCE, U. S. A.,
*Washington, D. C.*

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ALLEGHENY ARSENAL,
*Pittsburgh, Pa., October 26, 1888.*

SIR: In reply to your circular letter of the 12th instant, relative to making purchases of less value than $200 in open market instead of by advertising for proposals, as is now done, I have the honor to state that I am of the opinion that these small purchases can be made in open market with a much greater advantage to the Government than by advertising for proposals and yearly contracts.

There are responsible business houses in this city who will not bid under advertisements for small orders, claiming that they do not wish to incur the trouble and the formality of the present system. They also state that if they did bid that their prices would be considerably higher, on account of the contracts running for a year, than they would be if the purchases were made over their counter for cash. There is one firm in this city who are large manufacturers of brass cocks, lead pipe, iron gas pipe, etc., who will not bid for the above reasons, and from whom we could, under open-market purchase, obtain supplies at a reduction of from 10 to 15 per cent. less than our contract prices for the same articles, and this firm sells to plumbers and others who are our contractors at the same prices at which they would sell to us under open-market purchase, and the Government has to pay the increased cost.

Oats are selling here to-day at 33 cents per bushel; we pay 38 cents. Hay is selling at $16.50 to $17 per ton; we pay $20. Corn, shelled, at 52 cents per bushel; we pay 60 cents. Bran is $16 per ton; we pay $18. Oat straw at $8 per ton; we pay $12. And so on in the same ratio through the whole list of supplies that we have under contract, and I have no doubt that under open-market purchase the cost of the supplies would be reduced from 10 to 15 per cent.

Respectfully, your obedient servant,

GEO. W. MCKEE,
*Major, Ord. Dept., Commanding.*

The CHIEF OF ORDNANCE, U. S. A.,
*Washington, D. C.*

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AUGUSTA ARSENAL,
*Augusta, Ga., November* 3, 1888.

SIR: Referring to the proposition to amend section 3709, Revised Statutes, so as to permit open-market purchases of a less value than $200, I have the honor to state that it meets my heartiest approval.

We attempt to make prompt provision for future supplies by embracing in an annual catalogue every article of probable use, but there is such an infinitude of articles falling under the general denomination of "ordnance and ordnance stores," as well as of articles of general and occasional use in the shops and in the repair of machinery, buildings, inclosures, etc, that it is an absolute impossibility for any human being to foresee and provide for their purchase in time to have them available when needed. Or, in case a catalogue were made so comprehensive as to embrace every item of probable use, and these articles were bid upon and contracted for in good faith by responsible parties, and not ordered during the year because not needed, the contractors assume that the officers of the Government are trifling with them and they will not bid a second year. Business men do not care to go through the formalities required for nothing. In fact, unless personally solicited, they will seldom bid on any item or items. And this personal solicitation, as it can not be general, is directly contrary to the spirit of the law. An officer, therefore, must either break the law in attempting to enforce it or he may be charged with failure to provide for his post. He is impaled either way.

Again, our annual contracts call for "greater or lesser" quantities than stipulated for, and contractors are going to see that they are on the safe side. They must provide for possible rises in the market value of stores during the fiscal year, so that ordinarily our prevailing rates are much above the current market rates.

There are many small but very necessary items, which are only dealt in by special dealers, upon which we can seldom get a bid; as, for instance, charcoal for use in the shops. Our annual consumption of this article will average 25 or 30 bushels. This at 10 cents per bushel is $2.50 or $3; not worth contracting for, yet absolutely essential. I could name many other similar items, but this one illustrates the case. We had no charcoal for two years except that I could beg or pick up.

I have repeatedly bought small items for necessary use and paid for them from my own funds, because we could not otherwise obtain them. Yet I do not presume that Congress gives me my salary to run this arsenal upon.

Some two years since we needed a horse to replace a dead one. Bids were called for, time and place fixed for opening proposals, and the hardest lot of broken-down old animals were presented that could be gathered together in Augusta. I had either then and there to make a selection or do without a horse, or call for new bids to go through a similar selection. The limit was fixed at $175, while the best horse presented was only priced at $160. I would not have bought him in open market at any price, but he was the best of the lot.

During this year we may need castings of brass or iron to replace broken parts of machinery, tools, etc., but the patterns can not be known beforehand. They may be unique and complicated. No foundryman will contract for so small an item when the chances are that he may lose money.

I am certain the proposed amendment would prove advantageous to the Government and relieve officers from very frequent embarrassing and even ridiculous situations.

Very respectfully, your obedient servant,

J. W. REILLY,
*Major, Ord. Dept., Commanding.*

The CHIEF OF ORDNANCE,
*Washington, D. C.*

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FORT MONROE ARSENAL,
*Fort Monroe, Va., October* 16, 1888.

SIR: In compliance with instructions contained in your circular letter dated October 12, 1888, I have the honor to report that my experience in the purchase of small lots of stores under the present system of advertising for proposals has shown that it entails loss upon the United States by reason of the higher prices asked when proposals are required, the delay caused by the requirement to wait a certain period after advertising before opening bids, and the frequent necessity for advertising a second time with requests to dealers to make bids, none having been made under the first advertisement. By open purchase, without the formality of proposals, lower quotations can generally be obtained and a promptness in delivery, which is frequently of very considerable importance.

There is an unwillingness on the part of the larger business houses to make proposals in competition for small lots of material; their reason being that the profit is not sufficient to pay for the trouble of making formal proposals; and houses that do make proposals add enough to the real value of the articles bid on to pay for their trouble.

To note instances: I advertised in April for a small lot of oak lumber to make securing stakes that were required for immediate use at Fort Monroe; no bids were received, and a second advertisement was made which elicited but two bids specially requested. The lower was accepted at $70 per thousand feet, and the lumber was received in June—more than a month after the first advertisement. The contract for anthracite coal for use during the current fiscal year was awarded to the lowest bidder at $7.50 per ton. It can now be bought in open market at $7 per ton. The lowest bid received for yellow-pine flooring was $40 per thousand. The market price was $32.50. The lowest bid for yellow-pine scantling was $35, and it is selling for $30. The bids for cypress piles was $20 each. They can be purchased for $10.

The bids for lumber and piles were rejected, the prices being regarded as excessive. It will be necessary to advertise again for these articles when needed.

Respectfully, your obedient servant,

ISAAC ARNOLD, Jr.,
*Major, Ord. Dept., Commanding.*

The CHIEF OF ORDNANCE,
*Washington, D. C.*

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INDIANAPOLIS ARSENAL,
*Indianapolis, Ind., October* 17, 1888.

SIR: In compliance with the circular letter of the Department dated October 12, 1888, I have the honor to report that while the nature of my duties for some years past has been such that my experience in the purchase of supplies has been but limited, yet it has been sufficient to show beyond question the disadvantages of making small purchases by the present method. I can not recall an instance when such purchases could not have been made at cheaper rates by buying in open market; and when the time and trouble incident to making bids and executing contracts are considered, it is useless to discuss reasons for the unreasonable prices now necessarily paid for supplies furnished in small quantities.

Very respectfully, your obedient servant,

CLIFTON COMLY,
*Major, Ord. Dept., Commanding.*

The CHIEF OF ORDNANCE, U. S. A.,
*Washington, D. C.*

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UNITED STATES POWDER DEPOT,
*Dover, N. J., October* 17, 1888.

SIR: Referring to the efforts of the Department to have section 3709 of the Revised Statutes modified so as to exempt from its operation small purchases of less value than $200, I have the honor to report that my experience here and elsewhere has been that the section alluded to often operates to the disadvantage of the United States. Dealers frequently are unwilling to make formal bids for small orders, and when requested to do so to accommodate the requiring officer add to the cash price something for their trouble. Others again quote prices higher than market ones, indifferent as to the result of their bids, but sure of a good price if they are accepted. Great saving of time, labor, and money would result to the United States if the exemption asked for were granted.

Very respectfully, your obedient servant,

FRANK H. PHIPPS,
*Major, Ord. Dept., Commanding.*

The CHIEF OF ORDNANCE, U. S. A.,
*Washington, D. C.*

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SAINT LOUIS POWDER DEPOT,
*Jefferson Barracks, Mo., October 20*, 1888.

SIR: In reply to your inquiry as to the bearing of my "experience in making small purchases by the present methods of advertising for proposals," I have to state that my experience as disbursing officer at both large and small arsenals and depots justifies, as a wise and economical measure, your recommendation that section 3709 of the Revised Statutes shall not apply to purchase of supplies of less value than $200; also, that all the statements in your letter are borne out by facts within my knowledge.

The law may be wisely and skillfully framed to protect the interests of the Government and individuals in large transactions, but it certainly operates to the disadvantage of the Government in the many small purchases which yet aggregate thousands of dollars in the course of a fiscal year, and is, besides, a constant source of embarrassment and annoyance to both purchaser and dealer.

The application of the law to small purchases is, indeed, considered by the business man as rather farcical, and usually defeats the desire of the officer to procure the best goods at the lowest prices.

I have known at Watertown Arsenal a few trifles to cost several times their market value through a rigid enforcement of the law. As a rule, such extravagance can now be avoided; nevertheless it is only large purchases which can be advantageously placed for the Government.

Let me also instance formal articles of agreement in quintuplicate, with all the accessories of witnesses, red seals, etc., forming a contract for the delivery of one barrel of salt at $1.25 at this depot. (See formally approved contract between Daniel Paule, jr., and Maj. John A. Kress, December 26, 1886.)

Every-day experience at my present station illustrates the unsatisfactory working of the law and the wisdom of the suggested modification.

Advertisements for proposals for supplies for this depot were placed in only three newspapers this year; but the cost, with printing of catalogues, etc., will amount to over 15 per cent. of last year's purchases. This year the purchases will probably amount to $1,500, involving no less than seventeen separate contracts, each in quintuplicate.

Taking no account of time and labor, the cost of advertising, completing contracts, printing, etc., will add fully 10 per cent. to the cost of the article purchased, which, in spite of every reasonable effort on my part, will not average as well in quality as those I could inspect and purchase and "bargain" for in open market.

A law should not be capable of this absurd application; yet instances of this kind are the rule and not the exception in small purchases. There are instances where a liberal construction of a law will serve the public interests, but this appears to have been impossible with this cast-iron statute.

The entire commercial fabric of the world is based upon a system of credits and mutual confidence, and business firms—though their agents deal in dollars where we deal in cents—have no more perfect system of money and property accountability than that of our disbursing bureaus, and this system may be trusted to amply protect the interests of the Government in purchases of any amount. As to fraud in transactions under $200, if we are to discuss that infinitesimal danger, the mere formality of a contract is quite powerless to prevent it, as collusion between parties would probably be quite as easy upon a contract blank as upon any other form of voucher. If an officer be inclined to stain his honor and risk an honorable life position there is nothing in the present system to prevent him from doing so, unless it be the cheapness at which he would sell himself, for, the general market rates being known at the heads of Departments, the margin for peculation is certainly small.

Often no attention is paid to advertisements; indeed this is the rule with large dealers. In response to my last advertisements in the form and manner prescribed by the War Department, and costing $101.56, I received only two inquiries, covering two items out of one hundred. Failures of this kind being the rule, printed catalogues and "slips," are prepared at the War Department to be sent by mail to business houses. Even to these I had few responses until I had made personal appeals, and as a result, $100 or $200 worth of material is divided among several large dealers who have done me the favor to bid.

The larger houses, with which it would be of advantage to deal, as a rule care little for the Government patronage, and if they can not have it by standard commercial methods do not wish it at all.

I have known a firm after submitting prices and having them accepted for several thousand dollars' worth of material, politely decline any further dealings by contract with the Government, while glad at all times to sell goods for cash or credit as to other customers. I refer to General P. V. Hagner and N. & G. Taylor, Philadelphia.

The Nelson Manufacturing Company threw my circulars, etc., into the waste basket. Their agent "did not want to bother with small dealings extending through an entire year." A member of the firm stepped forward and instructed him to "give Captain Butler what he wants." The charity was accepted, of couse, in the interest of the Government.

The Rumsey Manufacturing Company, the Simmons Hardware Company, the Shapleigh and Cantwell Hardware Company, all the harness and saddlery companies, the stove, mantel, and grate houses, in fact, four-fifths of the dealers in the special articles wanted paid no attention to advertisements and circulars, and submitted their bids only upon personal solicitation.

Now these men did not abate one cent from their regular prices; they made no effort to "compete;" they simply gave me the prices of their goods, putting it in the form of bids as a personal favor, and the result is that, to get what is required, contracts have to be made with all of them at certainly not less than market rates; and to these prices must be added the cost of completing contracts, advertising, printing, etc. My personal expenses to and from and about the city may amount, during the two months of placing and accepting the bids, to about $25;

# APPENDIX 11.

## *REPORT OF THE PRINCIPAL OPERATIONS OF THE ROCK ISLAND ARSENAL, ILL., FOR THE FISCAL YEAR ENDING JUNE 30, 1891.*

### ROCK ISLAND BRIDGE.

During the latter portion of the fiscal year the upper or railroad deck of the main span of the Rock Island bridge was renewed by substituting a built iron floor beam for the rolled iron beams, and iron stringers for the wooden stringers and wooden floor beams composing the same.

The two elevated shore spans were also renewed by substituting heavier channel bars, in the lower chords, for those in use, and the building of an iron deck; all this in accordance with the act of Congress approved August 30, 1890, appropriating $68,000 therefor.

These improvements were rendered necessary by the increased weight of the modern railroad rolling stock, as well as by the decayed condition of the supporting timbers.

The change has made this deck perfectly safe for the passage of the heaviest engines and trains, and gives this portion of the structure a very handsome appearance.

The contractors for the work upon the main spans of the bridge, the Phœnix Bridge Company, of Philadelphia, in their renewal work suspended hangers from the top chords, so as to hold up one or two panels of the railroad deck while taking out the old crossbeams and putting in the new beams and stringers, thus interrupting the travel upon the bridge for only a few minutes at a time.

The old beams, with few exceptions, were removed intact, by cutting out enough of the filler in one of the columns of each opposite pin, so as to allow the old beam to drop down and out.

The new beams and stringers were then placed in position, and partially riveted up.

In this way the work progressed at the rate of about four panels per day; evenly and expeditiously.

The erection of the iron work was followed by the riveting and painting, every field rivet in the entire structure, as well as many shop rivets, was carefully tapped and inspected.

Some old cracks in the vertical columns were brought to light during construction and carefully noted down, but none are considered serious.

The contractor for the work upon the shore spans, the Lassig Bridge and Iron Works, of Chicago, Ill., while renewing this upper deck held up their spans by staging or false work.

In each span all the pins were found to cut the channel chords more or less, and they were all replaced, with the exception of the four end pins, which were corroded and worn in to such an extent as to prevent their removal without injury to the adjacent parts.

that this is the only true, business like method to adopt; and should a merchant adopt the policy now in use by the Government he would soon have to give away to his more enterprising neighbor. Not only are the stores of poorer quality (for it is hard to so express a contract as to cover all points of excellency), but the additional cost is at least 10 per cent. more, as reliable merchants prefer not to "fool," as they call it, with a contract, but will sell in open market.

Very respectfully, your obedient servant,

MARCUS W. LYON,
*Captain, Ord. Dept., Commanding.*

The CHIEF OF ORDNANCE, U. S. A.,
*Washington, D. C.*

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FORT LEAVENWORTH ORDNANCE DEPOT,
*Fort Leavenworth, Kans., October* 17, 1888.

SIR: In reply to your circular letter of the 12th instant, with reference to purchase of supplies of less value than $200, I have the honor to state that in my experience as commanding officer of this depot, the only purchase made exemplifies the necessity of your recommendation. I was authorized to obtain, in the usual way, 4,000 feet of lumber, and the only bid received in reply to my advertisement was for an amount about double what I knew it could be purchased for in open market. This bid was of course declined, and in answer to a new advertisement other dealers were induced finally to bid at the same prices they charged in open market, and the lumber was obtained after a delay of about one month.

As the officer in charge of the Proving Ground at Sandy Hook for several years, I was a constant witness of the embarrassment and disadvantage to the Government arising from the application of section 3709 of the Revised Statutes to small purchases, but such cases as I recall will be quoted probably by others.

I may state, however, that, as a consequence of it, I have been obliged to purchase small articles at my own expense to prevent the destruction of Government property.

Very respectfully, your obedient servant,

C. W. WHIPPLE,
*Captain, Ord. Dept., Commanding.*

The CHIEF OF ORDNANCE, U. S. A.,
*Washington, D. C.*

# APPENDIX 10.

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## REPORT OF THE PRINCIPAL OPERATIONS AT THE COLUMBIA ARSENAL, COLUMBIA, TENN., DURING THE FISCAL YEAR ENDED JUNE 30, 1891.

(One plate.)

### BUILDINGS.

Since my last report the following buildings have been completed under the contract made with Frank Goodwin, approved by the Chief of Ordnance, U. S. Army, January 24, 1890, viz:

Office, March 25, 1891; guardhouse, February 1, 1891; shop and chimney, March 6, 1891; stable and shed, February 1, 1891; barracks, March 6, 1891; married men's quarters, March 6, 1891; magazine, February 1, 1891.

The work on the commanding officer's quarters is approaching completion and this building should be ready for occupation on or about the middle of July.

The foundations and walls of storehouse have been completed to include the second story; columns, girders, and joists are in place on the first floor, and those for the second floor will be in place in a few days; completion of this building is anticipated on or before October 1, 1891.

The foundations of all the buildings are good; so far no signs of settlement have appeared on any of them.

The progress of the work on all of the buildings has been slow. Under the terms of the contract all of the buildings, except the storehouse, should have been completed before November 1, 1890, the delay on this work being due in some measure to the excessive wet weather in the winter and spring of 1890. The time for the completion of all the buildings, except the storehouse, was extended to February 1, 1891. The contractor failing to complete these buildings on that date, the time was again extended to March 1, 1891, for office, barracks, married men's quarters, and shop, and to May 1, 1891, for commanding officer's quarters. Another failure on the part of the contractor resulted in the extension of time for the completion of the office to March 15, 1891, and for completion of the commanding officer's quarters to May 15, 1891. Request made for further extension of the time for the completion of this latter building was disapproved. Application has also been made for the extension of the time for the completion of the storehouse, and is now held for consideration.

The experience of the past year confirms me in the belief that where the construction of buildings is contemplated the Department can do better work by days' labor than can be secured under a contract; and if the expense attending the supervision and inspection of the work under contract be taken into consideration, the difference in cost will always be in favor of the Department.

### SEWERAGE.

The sewerage system has been completed except the lateral connecting the storehouse and main, which can not be made until the contractor has completed his work on this building.

### PARTIAL PAYMENTS.

Paragraph 13, General Conditions, forming a part of the contract with Frank Goodwin, requires that payment be made at the request of the contractor, not oftener than once a month, based on an estimate made by the commanding officer of the amount of work done and the value thereof, according to the terms of the contract. In order to protect the rights of the contractor and to secure the Department against loss from overpayment on such estimates, it became necessary to make an estimate in detail for each building. The price of all kinds of material and labor had to be determined, the price for each class of material used on all of the buildings to be the same for each, and the amount apportioned to each, so arranged that their sum should equal the contract price for all. As no detailed estimate for any of the buildings had been prepared, this proved to be difficult and entailed a great deal of hard work. Had I not had the price of material and labor, based on the experience of an accomplished officer of the Department at one of the largest arsenals, the problem would have been almost indeterminate.

If information in regard to the prices that prevail for material and labor in general use at the large establishments could be supplied to the commanding officers of smaller arsenals, not oftener than once a year, I believe it would prove to be a great benefit. The cost of all work of the same character would approach uniformity throughout the Department. Officers undertaking work without experience would be in possession of reliable data with which they could form an idea of what should be a reasonable cost of such work and be relieved of great anxiety at the outset. Estimates in detail having been prepared, the making up of estimates for partial payments was greatly simplified and complete protection against overpayments was secured.

The amount apportioned for the construction of each building under the contract was as follows:

| | |
|---|---|
| Storehouse | $91,373.20 |
| Commanding officer's quarters | 21,170.33 |
| Office | 10,865.54 |
| Guardhouse | 3,954.92 |
| Shop and chimney | 14,441.12 |
| Stable and shed | 4,525.19 |
| Barracks | 10,750.10 |
| Married men's quarters | 8,492.90 |
| Magazine | 5,748.70 |
| Total | 171,322.00 |

### MORTAR.

Neat Portland cement was used in the construction of the sewerage system.

The foundations of the storehouse are laid in mortar composed of black diamond cement and sand, one part cement to two parts clean, sharp sand. For the superstructure of this building, foundations and walls of all other buildings, the mortar was composed of one part black diamond (Louisville, Ky.) cement, one part lime, and two parts sand.

The Louisville Cement Company requested that the cement be inspected at their works before shipment, so as to prevent loss to them by return freight on rejected packages. As this could not be done, the contractor, at my suggestion, employed experts to inspect the cement at the mills before shipment to this arsenal. Certificates of inspection were forwarded with each lot; samples from each lot received were carefully inspected and tested for tensile strength. So far the black diamond cement has proved to be uniformly good.

The following instructions were given the inspector in regard to the slacking of the lime and the mixing of mortar for use on all the buildings, viz:

> The ordinary method of slacking lime consists in placing the lumps in layers 6 or 8 inches deep in either a water-tight box or a basin formed in the sand, to be used in mixing the mortar, and pouring upon the lumps a quantity of water from one to three times the volume of the lime. The proper proportion of water to be used with the lime depends entirely upon its nature and characteristics, and can only be determined by actual experiment. The object to be attained is the thorough slacking of the lime *without stirring* or the addition of more water and the formation of a thick lime paste. The lime paste must be thick and unctuous; thin paste that flows easily like cream is not desirable and will not be accepted. Whilst slacking stirring of the mass or the addition of more water injures the product; neither will be necessary if proper care and good judgment is used at the beginning of the operation. Practices of this kind will not be tolerated. A competent workman must be in charge of this part of the work. Covering the bed of lime with a tarpaulin, or with a layer of sand, retains the heat and accelerates the slacking. All lime necessary for any required quantity of mortar should be slacked at least one day before it is incorporated with the sand; *after this* the sand (in the proportion of two to one of lime paste) should be spread evenly over the paste and the ingredients thoroughly mixed with a shovel or hoe, a little water being added occasionally if the mortar is too stiff. One barrel (230 pounds) of lime should make about 8 cubic feet of stiff paste.
>
> Mortar in the above condition should be kept at least seven days; at the end of which time the cement can be added in the proportion of three of mortar to one of cement, to be incorporated in such a manner that the cement shall be uniformly distributed throughout the whole mass.

These instructions have been rigidly enforced; also samples of the mortar in daily use were taken from the mortar boards every day and made into bricquettes, which were tested for tensile strength after exposure for periods of time varying from seven days to six months. The results of these tests are shown in the attached diagram (Plate I), also the tensile strength of neat Portland cement and neat black diamond cement, determined by tests made here, together with strength of cement mortar prepared for use on the foundation of the storehouse.

The results are compiled from the breakage of about 2,000 bricquettes and represent the fair average strength of the mortars in daily use at this arsenal. The neat cements were made into bricquettes and allowed to set in the air; samples so formed were tested at the end of twenty-four hours. Those tested at the end of one week, one, two, four, and six months were placed in water some time previous to the breakage. It was noticed that neat Portland cement had about the same tensile strength whether the bricquettes were allowed to remain in the open air or water, but bricquettes of black diamond cement showed a decided increase of strength when allowed to stand in water after setting. As the foundations of the storehouse were laid in the fall and winter months, during the prevalence of a great deal of wet weather, bricquettes of the mortar in use were made and allowed to remain in water until tested, so that their condition might be as near as practicable the same as that of the mortar in the walls; bricquettes of the same mortar exposed to the air were also tested.

Bricquettes of mortar composed of one part black diamond cement, one part lime paste, and two parts of sand were tested after remaining in the air and after remaining in water, the latter showing a perceptible increase in strength over the former, and it is believed they represent a fair average strength of the mortar used in the walls of all superstructures.

### IRON WORK.

The columns for the first and second story of the store-house were made by the Cahill Iron Works at Chattanooga, Tenn., and were carefully inspected. They appear to be castings of tough gray iron, straight and smooth and of uniform section. Having no means of testing samples for tensile or crushing strength this test had to be omitted, but careful calculations made with Hodgsen's formula and formula taken from the Ordnance Manual show that they are abundantly strong, the factor of safety being above six. The girders, formed of two steel I-beams, were made by Carnegie, Phipps & Co., Pittsburgh, Pa., each beam being stamped with the name of the makers. Careful inspection of them were made and they appear to come up to the specifications in all respects.

### STONE.

With the exception of the foundations, the stone used in the construction of all the buildings is an oölitic limestone, taken from the quarry near Bowling Green, Ky. When first quarried this stone is a light brown or dove color, changing to a light gray (nearly white) color when thoroughly seasoned. It is quite soft and porous when taken from the quarry, absorbs water freely, and hardens on exposure to the weather. When laid in the walls with a mortar composed of lime, cement, and sand stains soon make their appearance on the outer surface. In some cases the stone appears to be coated with a thin deposit, almost black in color. These stains disappear under the continual action of the weather. The first appearance of these stains caused some alarm for fear they might prove to be permanent, and, believing they were due in a great measure to the pressure of the cement in the mortar, the idea of abandoning the use of the cement was entertained, but I observed that pure lime mortar also stained the stone, and as strength was an important item I concluded it was advisable to retain the cement. Experience here leads me to believe mortar stains on this variety of limestone are not permanent in character, and that all such stains will disappear in time if care is used in the selection of the stone. The stone carries quite a large percentage of petroleum. Somea ppears to be saturated with this substance. It can always be detected by its dark color and odor. Such stone, although apparently of good quality, should be rejected or not placed in the walls until after it has been thoroughly seasoned. This process may be shortened during the summer months by keeping the stone saturated with pure water and exposure to the rays of the sun. Adopting this precaution, fears of mortar stains on this stone should not prevent the use of cement where strength in construction is desirable.

On the completion of the present contract with Frank Goodwin the appropriation of $200,000 for this arsenal will be expended, and all of the work contemplated by the Department will have been completed.

Provision should be made for quarters, fences, roads, walks, grading grounds, shade trees, fertilizers, water supply, gas mains, etc.

Respectfully,

Isaac Arnold, Jr.,
*Major, Ord. Dept., U. S. Army, Commanding.*

(5266–'91.)

# APPENDIX 11.

## *REPORT OF THE PRINCIPAL OPERATIONS OF THE ROCK ISLAND ARSENAL, ILL., FOR THE FISCAL YEAR ENDING JUNE 30, 1891.*

### ROCK ISLAND BRIDGE.

During the latter portion of the fiscal year the upper or railroad deck of the main span of the Rock Island bridge was renewed by substituting a built iron floor beam for the rolled iron beams, and iron stringers for the wooden stringers and wooden floor beams composing the same.

The two elevated shore spans were also renewed by substituting heavier channel bars, in the lower chords, for those in use, and the building of an iron deck; all this in accordance with the act of Congress approved August 30, 1890, appropriating $68,000 therefor.

These improvements were rendered necessary by the increased weight of the modern railroad rolling stock, as well as by the decayed condition of the supporting timbers.

The change has made this deck perfectly safe for the passage of the heaviest engines and trains, and gives this portion of the structure a very handsome appearance.

The contractors for the work upon the main spans of the bridge, the Phœnix Bridge Company, of Philadelphia, in their renewal work suspended hangers from the top chords, so as to hold up one or two panels of the railroad deck while taking out the old crossbeams and putting in the new beams and stringers, thus interrupting the travel upon the bridge for only a few minutes at a time.

The old beams, with few exceptions, were removed intact, by cutting out enough of the filler in one of the columns of each opposite pin, so as to allow the old beam to drop down and out.

The new beams and stringers were then placed in position, and partially riveted up.

In this way the work progressed at the rate of about four panels per day; evenly and expeditiously.

The erection of the iron work was followed by the riveting and painting, every field rivet in the entire structure, as well as many shop rivets, was carefully tapped and inspected.

Some old cracks in the vertical columns were brought to light during construction and carefully noted down, but none are considered serious.

The contractor for the work upon the shore spans, the Lassig Bridge and Iron Works, of Chicago, Ill., while renewing this upper deck held up their spans by staging or false work.

In each span all the pins were found to cut the channel chords more or less, and they were all replaced, with the exception of the four end pins, which were corroded and worn in to such an extent as to prevent their removal without injury to the adjacent parts.

The north shore span was found to be on one lower chord, about 1 inch, and on the other 1¾ inches, below a level line, and was necessarily left in the same position.

The south shore span had a camber of about one-half inch, which was maintained.

After the completion of the renewal of the deck, the Rock Island Railroad Company placed their ties and guards in position and painted them; at the same time we placed in position the new copper work for draining off the water, and for the protection of the wagon traffic on roadway below from the dropping of the engines and the cars.

This copper protection, as shown in detail in Pl. VIII, was nearly all made from the copper taken from the old deck, and has thus far worked very satisfactorily.

The new locks for the draw are strong, light, and easily worked.

The iron in the entire structure was carefully inspected by officers of the Department, and all tests show it to have an elastic limit in excess of the requirements—25,000 pounds per square inch—and a tensile strength of from 48,000 to 52,000 pounds, according to its class.

The iron for the main spans was manufactured by the Phœnix Bridge Company, that for the two shore spans by Carnegie, Phipps & Co.

All the work was done in a first-class manner, and was carried on with but very little interruption to the railroad, wagon, and foot traffic, and no accidents occurred of any moment.

An extra guard was placed upon the bridge to stop the wagon traffic when beams were being raised or lowered, and to assist in the care of frightened horses.

Other repairs incident to renewing the upper structure of the bridge, such as repairing the roof, floors, and ceilings of the engine and boiler-room, new supporting platforms at operating apparatus at ends of the draw, were made, in a substantial manner.

The Western Union Telegraph Company replaced their tower for supporting the wires upon the draw span by a lower and stronger structure, better adapted to the increased service now rendered necessary.

The Davenport and Rock Island Street Railroad Company, having adopted an electric system for the propulsion of their cars, the power house of which is in Rock Island, have placed a system of safe and sightly brackets upon the upper chords for carrying their power wires over the bridge; these wires pass through a cut-off switch at the south abutment, which is under the direct control of our guard.

The People's Light and Fuel Company, of Moline, Ill., whose wires also cross the bridge, will be required to replace their present inadequate brackets on the upper west chord by similar brackets, and a switch for use in case of accidents, or danger from live wires.

The entire bridge needs painting, for its preservation as well as for its appearance, which latter fact is strongly brought out by contrast of the newly painted surfaces with the old parts.

On the wagon bridge floor, the planking between the tracks has been partially renewed, as far as the appropriation for the care and preservation of the bridge would permit, and it will probably last, with minor repairs, until a new appropriation can be made.

The wooden beams supporting this floor have been turned over in former repairs and are rotten and very unsafe; they should be replaced by steel beams, which would allow repairs of the wagon floor to be made with partial instead of total interruption of the heavy traffic on this part of the bridge.

As it is of vital importance that this change be made so accidents may not occur, I would respectfully request that the attention of Congress be called to this matter, for if the renewal is deferred too long, there is liability of a startling and serious accident occurring.

The following is an abstract of the travel over the bridge during the year:

| | Passing north. | Passing south. |
|---|---|---|
| Engines with trains | 8,773 | 8,539 |
| Engines without trains | 210 | 480 |
| Total engines | 8,983 | 9,019 |
| Passenger cars | 13,842 | 13,835 |
| Freight cars | 124,590 | 124,565 |
| Foot passengers | 291,227 | 292,736 |
| Teams | 210,956 | 209,185 |
| Steamboats | 1,562 | 1,571 |
| Barges | 399 | 317 |
| Rafts | ........ | 833 |

### DRAW PIER.

The work commenced at the end of the preceding fiscal year of replacing the worn-out wooden structure connecting the upper and lower protection piers with the center pier of the draw by one made of stone has, during the fiscal year, been completed in a very satisfactory manner.

The coffer dam used in the course of its construction has been removed, and the wooden rests at the ends of the pier, which had become rotten, have been replaced by new timbers.

A neat and substantial house of corrugated iron has been erected upon this pier for the storage of tools, etc., making at the same time a commodious workshop for the repairs incident to the bridge work.

### RECONSTRUCTION OF THE WATER-POWER DAM WALL.

The work, commenced under such adverse circumstances the previous year, of reconstructing the arsenal water-power dam wall, has progressed the past year in a very satisfactory manner.

There have been purchased some 4,975 cubic yards of sandstone, from Berea, Ohio, 2,950 barrels of Dyckerhoff cement, and 266,000 hard brick; and there has been laid in the wall some 6,607 cubic yards of sandstone.

The wall has all been finished with the exception of the brick arches, the concrete filling, and the top course of stone laid upon these; the work upon this portion is progressing at a very rapid and satisfactory rate, so that by the end of the working season there will not remain much to be done upon it.

All the sills and gates have been made and are in place; the screens are in course of construction, and will be finished in time to be set in place when the pool is bare of water occasioned by the construction of the coffer dam in the water-power pool above.

One-quarter of the temporary dam has been removed, and as soon as the water is drained off it is proposed to remove the remainder of it, so that some time during the coming fiscal year the dam will once more be ready to supply our shops with power.

## IMPROVEMENTS OF THE WATER-POWER POOL.

Nothing has been done in the past year in regard to the improvement of the water-power pool, with the exception of making an accurate survey of the ground where it is proposed to work, in order to determine location of the general line of the coffer and in hauling from the pier such lumber and rods as were saved from the coffer used there and which will be of service in the work at the pool.

## SHOP K.

During the past year, beyond the cutting of 144 feet of flagging for the sidewalks, all the work upon this building has ceased.

## STOREHOUSE K.

During the past year the stone walls finishing the third story were laid.

The roof finished and gutters and down spouts put in, this work being a duplicate of similar work on storehouse A.

At present work is in progress to finish the windows and doors to protect the building from the weather.

Owing to the formation of the ground, an appropriation is asked for to complete the grading, flagging, and drainage of the ground surrounding this storehouse.

The shipments now being made from this arsenal overtax the capacity of the only storehouse finished, and if this is connected with the other by rail, as contemplated in the general plan of the arsenal, the service of this storehouse would aid greatly in the handling of ordnance stores.

These storehouses are admirably planned. Last winter during the Indian campaign we were able to load at storehouse A, in less than one hour, a carload of arms and ammunition and have them started on their way to the troops in the field.

The only thing lacking in them is a system of lighting, which, if the electric transmission of the power at the dam is adopted, can readily be supplied from there.

During the past year 1,484 issues were made to the Army, Navy, and militia, and receipts from the same sources amounted to 426.

## GENERAL CARE, PRESERVATION, AND IMPROVEMENT.

The great area of the arsenal, the number of its buildings, and the length of its walks and roads prevent any great amount of special work being done under this head with the limited appropriations available for this purpose.

As the buildings grow older it will require a larger sum each year to keep them in a good state of preservation. Private corporations and individuals consider that 1 per cent of the cost of a building is a small enough sum to spend in repairs, and I can but urge that the appropriations under this head be materially increased. If it is not done now it will only be a question of time when a much larger appropriation will be necessary to preserve the buildings.

During the past year, with the limited appropriations, all of the buildings have been examined, and where it was possible the doors and windows have been painted, the roof repaired, and the masonry repointed.

The main avenue has been remacadamized for 1,000 feet, repairs made in the macadam upon Fort Armstrong avenue, the fences have been painted, railroad track weeded, trees planted where old ones had died out, the bridge over the water-power canal replanked and strengthened, gutters rebuilt, and sidewalks raised upon the main avenue.

### MANUFACTURES.

During the year the equipment plant of Watervliet Arsenal has been transferred here, and all the work formerly done there is now included in our manufactures.

It has taken a little time to get sufficient numbers of skilled harness-makers here, but by making judicious selections we have succeeded in fully equipping our shops and are now prepared to execute all orders given us.

The standard of the work turned out has improved, and no complaints of any kind have been heard by us.

Respectfully,

M. W. LYON,
*Captain, Ord. Dept., Commanding.*

(5953-'91.)

# APPENDIX 12.

## *REPORT OF PRINCIPAL OPERATIONS AT WATERVLIET ARSENAL FOR THE FISCAL YEAR ENDING JUNE 30, 1891.*

(Two plates.)

### THE GUN-FACTORY BUILDING.

The north wing and central section of this building has, during the year, been completed from the condition in which it was at the beginning of the year, as noted in Appendix 12, Chief of Ordnance report of 1890, excepting

*The shrinkage pit*, upon which work has been slowly prosecuted, awaiting an appropriation to complete it and for a further consideration of the design of the furnaces. An appropriation of $14,000 for frame work and adjustable platforms and for drainage of the pit was made during the last session of Congress, and now the work is being pushed. The furnaces are being set and connected with the flues to the main stack, and the platforms, stairs, holding frames and supports for the guns are partly in. The 20-inch drain which connects at its upper end with a tunnel from the pit 23 feet under the shop floor, and at its lower end with the new drainage system to the river, is partly laid and will be finished this autumn. The tunnel will take longer to finish, but it has been commenced and the prospects for getting through with it this calendar year are good.

*The steam-power plant*, cranes, shafting, belting, heating pipes, electric-light plant for north wing and center have all been completed.

*The machine tools* for this wing have all been delivered, set up, and at work, except seven large turning and boring lathes for 8-inch, 10-inch, and 12-inch guns, and five turning and finishing lathes for the same calibers, two jacket lathes, and one rifling machine. These are contracted for, and three of the large boring lathes should, by the terms of the contract, have been at work by August 1, while at this date (September 1) only one is at work, so much behind are the contractors in their deliveries.

*Gun work.*—The shop was started up and the tools set at work first on November 9, 1890, and work on seacoast and siege guns has been pressed since to the fullest capacity of the plant. The lack of large boring and turning lathes of course cripples the shop and reduces the output, but the three old lathes in the small gun shop have enabled us to complete the 12-inch gun during the year, work on which was commenced in the preceding year; also a 10-inch cast-iron wire-wound gun and a 12-inch steel mortar were completed and sent to Sandy Hook. A 10-inch steel wire-wound gun is in process of construction, but has been delayed by the non-receipt of the jacket from the contractors. Twelve 8-inch guns are well along, and it is hoped to have them finished by the end of February next. Four 10-inch guns are being worked on, and another 12-inch gun. The forgings for other guns of these calibers will be taken up as they are delivered by the contractors.

Work is also going on principally in the small gun shop on twenty-five 3.2-inch field guns, ten 5-inch siege guns, ten 7-inch siege howitzers, and two field guns of experimental pattern. Orders are now outstanding for the construction here of 113 pieces of ordnance of all calibers.

*The south wing.*—The original plan contemplated a central section 166 feet long, containing the shrinkage pit, steam plant, small forge, shop, offices, etc., with two wings 400 feet long containing the machine tools. The center section and north wing have been built, but not until last session were the funds appropriated for the south wing. This wing is to be 30 feet wider than the present one to admit of building guns of a higher caliber than 12-inch, and will have an 80-ton crane, with lighter cranes in the west aisle; also a number of heavy-gun lathes longer than those in the north wing. Under an appropriation of $320,000, made August 18, 1890, contracts were entered into for the crane, 4 turning and boring lathes, 6 turning and finishing lathes, and 1 rifling machine for the south wing.

On February 24, 1891, a further appropriation was made of $268,000 for machinery, tools, power plant, etc., to complete the equipment of the south wing. Advertisements for bids were issued, and bids were received and opened on July 14 for 2 turning and boring lathes, 1 threading and slotting machine, 2 large jacket lathes, and 46 other smaller machine tools, consisting of lathes, cylinder boring tools, vertical boring and turning mills, slotters, planers, shapers, drills, milling machines, grinding machines, and screw machines needed for gun work, and contracts were made with different parties for their construction and delivery.

In the same bill was an appropriation of $248,743 for the erection of the south wing, inclusive of ways for traveling cranes.

Advertisement for bids for the work was issued, and the bids opened on May 21, and contracts made. Work has been in progress erecting the building since. So far the work has been well done, and it is expected that the masonry work will be finished before freezing weather. The roof can be rapidly put on and work inside be carried on in the winter. The plan of the south wing of the building is shown on Pl. I. The designs of the large lathes, specifications, etc., of machine tools, have before appeared in annual reports; I therefore submit the above brief résumé of the progress of the work without any designs appended.

*The manufacture of projectiles* has been carried on during the year to the fullest extent of the rather limited plant. This has, however, been considerably increased lately. In the fortification bill of August 14, 1890, $16,000 was appropriated for "increase of machinery and plant for the manufacture of projectiles and for castings needed in current work of gun fabrication." This money has been expended in the purchase of tools and fixtures for finishing and handling projectiles, also in enlarging and practically rebuilding the small inconvenient bronze foundry, in lighting and ventilating the iron foundry building, and in connecting it with the finishing shop by a tramway carried under the railroad bank. This, by the addition of the new cupola, increases greatly our foundry capacity, and the new machine tools permit of finishing the castings. Nine thousand eight hundred and sixteen projectiles of different calibers have been cast, and about 5 tons of machine castings additional.

*Field caissons, battery wagons with forges and limbers.*—The machine and carpenter shops have been fully engaged in the fabrication of these field caissons and battery wagons and other implements and equipments for the artillery arm. An order was received in October, 1890, for 25 caissons, 50 limbers, 6 combined battery wagons and forges with all their tools and equipment. These will be finished by the end of September. The list of articles fabricated appended to this report gives the other articles made during the year.

*New water-service system.*—In the sundry civil bill of August 30, 1890, there was an appropriation of $5,542 for this work. Advertisement for bids was made first October 6, 1890, and a contract was made with Charles Brown; he failed in the performance of his contract, and the work was the second time bid for May 1, 1891, and the contract was given out, and the work completed in June, 1891.

Seven hundred and sixty feet of 8-inch pipe, 985 feet of 6-inch pipe, and 1,415 feet of 3 and 4 inch pipe was laid and 7 hydrants set. This connects the arsenal with the West Troy Waterworks Company's supply and gives a head of about 70 pounds square-inch pressure, furnishing a security against fire, and, where it passes only through the new pipes, a supply of potable water. A well was also dug on the bank of the river and connected with it by a 12-inch pipe, from which the supply for manufacturing purposes is pumped into a large tank on the hill. The pumping is done by water power in the lower shops. A filter is placed in the well, and the system is so arranged that either the town water or the tank water can be used either for domestic purposes or for manufacturing as is desired. The specifications for this work are sent herewith.

*New sewerage and drainage system.*—This was much needed here, and an appropriation of $12,985 was made for both purposes in the sundry civil bill of August 30, 1890. The work was let at contract October 23, 1890, after advertisement, and was worked on during the autumn and winter, and was finished in the spring of 1891. Five thousand two hundred and eighty-five feet of pipe was laid, with 35 manholes, and catch-basins set where needed. The pipes are concentrated at one point where two 10-inch pipes pass under the canal and run to the river, giving plenty of fall for free drainage. The connection with the officers' quarters has not yet been made but is progressing, plenty of funds remaining for that purpose. The specifications are appended.

*New macadamized roads.*—In the same bill an appropriation of $10,000 for roads was made. Advertisement for bids resulted in a contract, made October 29, 1890. Some work was done in the autumn, but it was suspended during the winter and resumed in the spring, and the amount that the appropriation admitted of was completed in June, 1891. Two thousand nine hundred and thirty-three lineal feet of road, 441 feet of sidewalk flagging, and 2,096 feet of gutters were laid. Considerable paving should yet be done to the roads. This is a rainy climate, and heavy roads have in the past been an inconvenience at this arsenal. The specifications are sent herewith.

*Wash-room and sinks for the gun factory.*—In the fortification bill of August 18, 1890, an appropriation for this building was made, the amount being $12,000. It was contracted for in December, 1890, and was built in the winter. It consists of a one-story brick building connecting the large and small gun shops by a passageway. It contains a large room with washing troughs with hot and cold water. Clothes closets with lock and key, one for each operative, are built around the wall. Two offices for timekeeper and subforeman and the privy for the men are on the opposite side of the passageway. The power transmission from the large shop to the small one is overhead in this passage; also the electric-light wires and steam heating pipes pass from one shop to another through this passage. Probably another privy will have to be built near the south end of this long shop. A plan of the building is shown on Plate 11, and specifications are appended hereto.

*Additional railroad sidings and scale switch.*—It was found necessary to have more sidings to prevent delay in loading and unloading cars; also to move the scale to a more convenient place for weighing, and in the same bill of 1890 $2,800 was allowed for the purpose. The work was done by contract in the spring of 1891. A new siding 530 feet long, and a scale switch 360 feet long, with all the necessary switches and conveniences for using, was provided by the contractor, and the scale was removed and properly set anew. It greatly facilitates weighing and switching.

*New steam engine for machine shop.*—In the same bill above mentioned was an appropriation for a 150 horse-power engine to replace the old one at the lower shops. A Corliss engine and some shafting and pulleys were put in by contract during the spring of 1891. It has worked satisfactorily since its erection.

*Increased facilities for shipment by water.*—One of the most desirable improvements for facilitating work at the gun factory is proper means for shipping and receiving heavy guns by river. There had been purchased a 50-ton hand-power crane, but it was never of any use either at the wharf or anywhere else. It was planned to lengthen the reach of this crane and increase its capacity to 60 tons, and to set it on the wharf; also to dredge the bottom along the wharf and out to the river channel, to give all the depth of water needed for shipping the heaviest guns.

The dredging was kindly done at my request by the U. S. Engineer Corps, by authority of Lieut. Col. Gillespie, in charge of the river and harbor improvements in this locality. The alteration of the crane is nearly completed, the foundation built, and the crane will be set and the work completed this autumn. A 12-inch gun can then be swung from a railroad car onto a barge, or the reverse, and a very necessary adjunct to the gun factory will thus be secured.

*General improvements, repairs, and preservation.*—Much work has been done in grading grounds, repairing old and making new gravel roads, and repairing fences and public buildings. Nine thousand cubic yards of earth excavated for the foundations of the south wing of the gun-factory building was hauled and used in filling in low wet ground, principally between the east front of the barracks and the canal. This marshy field could not be cultivated and has heretofore been regarded as injurious to the health of the post. Filling and grading has also been done on the east of the hospital and on the west of the new quarters. Catch basins have been put in at different low points towards which the grounds incline, and subdrains are laid to carry off the water and dry the soil. All this will improve the appearance and the sanitary conditions of the arsenal. One thousand two hundred feet of new broken-stone and gravel roads have been laid and old ones have been kept in repair.

Issuing and receiving stores and material incident to a large arsenal and consequent upon the prosecution of a good deal of work has been efficiently carried on during the year. Also the great amount of clerk work necessitated by the accountability and the business transactions has been done by the skilled clerks, at the expense of much labor and unvarying industry.

Respectfully,

F. H. PARKER,
*Lieut. Col., Ord. Dept., U. S. Army, Commanding.*

(6697-'91.)

## *APPENDICES TO REPORT OF PRINCIPAL OPERATIONS AT WATERVLIET ARSENAL FOR THE FISCAL YEAR ENDED JUNE 30, 1891.*

### *Specifications for the proposed water-service system at the Watervliet Arsenal.*

It is intended to reconstruct the existing water system at the arsenal by the addition of new pipe lines in such a manner as to obtain a supply from the mains of the West Troy Water Works Company; also to furnish a supply of river water for manufacturing purposes. But in dividing the service thus it is intended to have such connections made as will allow at any one time to draw a supply either from city water or river water through the whole system.

The supply of city water will be made by means of an 8-inch main and a 4-inch "pass-by" at A, at or near the intersection between Sixth avenue and the arsenal wall, and by means of a 6-inch connection on Broadway at B. The 8-inch main is to be provided with an 8-inch gate valve, the 4-inch "pass-by" with a 4-inch gate valve and a 4-inch water meter, and the 6-inch connection on Broadway with a 6-inch gate valve. The new 8-inch main leads first in a southerly direction from A to C, thence in an easterly direction to a point, D, where connection with the present 8-inch main must be made by means of a Tee and two 8-inch gate valves.

A 4-inch connection will be made at E to supply a hydrant, $H_1$. Another 4-inch connection at F will supply a hydrant, $H_2$, while a 2-inch wrought-iron pipe connection must be made from point G with the water service of the cottage at I.

At K, near the intersection of the existing two 8-inch pipes running in opposite directions, an 8-inch gate valve must be interposed west of the point of intersection.

At L a 6-inch connection must be made from the existing 8-inch pipe to a hydrant, $H_3$. At a point, M, near the wall of the small gun shop connection must be made with the 4-inch galvanized wrought-iron pipe supplying water to the boiler, and a 3-inch pipe must be laid therefrom to a point, N, with a 2½-inch nozzle at N and O for the water supply at washroom and water closets.

A 2-inch wrought-iron pipe connection must be made between a point, P, of the existing 8-inch pipe and the east wall of the hospital, where it is to be jointed to the water pipe leading into the building. At a point, R, a 4-inch connection must be made with a hydrant, $H_4$.

At a point, S, a 4-inch gate valve must be interposed into the pipe leading to a hydrant near the commanding officer's quarters. At a point, T, a 4-inch connection must be made with the existing 8-inch pipe, with a 4-inch pipe leading to a hydrant, $H_5$. A 2-inch pipe connection is to be carried from that point to the two officers' quarters, $Q_1$ and $Q_2$. This latter pipe must be suitably connected with the water service of both quarters.

The existing water main which crosses under the Erie Canal at U is supposed to be an 8-inch pipe, and terminates at or near a point, V. From this point a 6-inch pipe must be laid as shown on the map, and connected with the 8-inch city water main on Broadway at B.

This 6-inch pipe is to have a 6-inch gate valve near its connection with the 8-inch city main on Broadway, and is also to be provided with a 6-inch gate valve at W and with a 4-inch connection to a hydrant, $H_6$. At J a 2-inch cross connection must be made and connections with the existing water-supply pipes for office and guardhouse must be made. At X a 4-inch cross connection is to be made, the northern branch of which must supply a hydrant, $H_7$, while the southern branch must supply a hydrant, $H_8$, and terminates at Y. A 3-inch pipe is to be laid and connected with the existing 3-inch pipe at a point, Z, to supply a hydrant, $H_9$.

The new water-service system is shown on the accompanying map; also all proposed connections, direction of pipe lines, and location of hydrants.

At G, P, $H_5$, and J brass stopcocks must be interposed into the 2-inch pipes supplying houses.

All ditching and filling must be done by the contractor, and the bottom of all pipes must be 5 feet below the ground, except where otherwise directed by the commanding officer.

The contractor is to furnish and put in place and connect properly all pipes, hydrants, valves, gate boxes, water meters, and all other material required for the proper execution of the work.

All pipes must be laid straight and properly drained, all joints to be calked with lead.

The whole system is to be delivered water tight, and no part of the system must be covered before having stood satisfactorily the pressure of the water in the city mains.

All pipes must be of cast iron except where otherwise stated.

parts of sand. The mortar to be well and thoroughly mixed. No air-slaked lime to be used. The bricks to be thoroughly wetted before laying, except when otherwise ordered by the commanding officer. Every brick to be completely imbedded in mortar. Care shall be taken to have every joint full of mortar. Competent mechanics shall be employed for this work. All bricks shall be laid close, straight, and plumb, well flushed in and properly bonded with one course of headers to every six courses in height. All joints on exterior of walls to be neatly pointed with black mortar and flush on interior.

Facing brick to be of uniform color, as much as possible. Brick arches to be turned over all doors and windows (except transom windows) and other openings, as shown on plans. All arches to be double, 8 inches thick, except where shown otherwise.

Contractors will furnish and set in place all window and door sills, and the water table around walls of wash room and offices. Walls on either side of passage and walls of passage to have no water table. All sills and water table to be of North River blue stone, free from any defects, and similar in appearance and finish to those of the new gun-factory building. All sills to be made in one single piece, and to be 2 inches longer on each end than width of door and window frames. All window sills and water table to be 8 inches wide by 5 inches thick; all door sills to be 18 inches wide by 5 inches thick, and to be provided with mortices for door-jambs. All sills and water table to have proper wash. No stone sills are required for interior doors and windows. All stones to be cut to exact dimensions, and all angles and arrises shall be true and well defined. All beds and builds shall be dressed for the full width of the stone. All cut stone to lie on its natural bed and to be well bedded in pure domestic cement of approved quality. All anchors for securing roofs to walls, also all other anchors required for the completion of the building, will be built in by the contractor.

The top of all walls to be covered over with a coat of cement mortar. The walls of the passage must be tied into walls of shop buildings.

All gable walls to be anchored to purlins of roofs at intervals of 6 feet by wrought-iron anchors 2 x $\frac{3}{8}$ inch, built into walls. All anchors and bolts to be furnished by the contractor for the carpenter work.

All cornices are to be of brickwork, and to be built as shown in elevations and details. They must be well bonded and neatly built and painted up. The contractor is to cut out or build up after carpenters, roofers, plumbers, or other contractors everything necessary to complete the building.

The contractor is to clear the building and site from all refuse and rubbish, to do all refilling and grading about the walls, and to leave in neat condition the grounds occupied by him. He is to give all facilities to other contractors for performing work adjoining his own, and any difference which may arise between two contractors in regard to their adjoining work is to be adjusted by the commanding officer. His decision is to be final in the matter. The mason work must be prosecuted uniformly and steadily, and no part of any wall shall at any time rise more than 3 feet above the rest. All unfinished work must be raked back, as may be directed by the commanding officer in each case, and before new work is joined to its surface the bricks must be scraped clean, scrubbed with a stiff brush, and well moistened.

All interior surfaces of walls above floor line to receive two heavy coats of whitewash after the building is under roof.

### CARPENTER WORK.

The carpenter work comprises all work on roofs, except tinning and slating, on the floors and ceilings of office rooms and passage between them, on the covered way leading to and around water-closet, and all windows and doors. The lumber for the wooden floors in passage between shops and the clothes closets in wash rooms will be provided by the Ordnance Department. The contractor has to lay the floor in passage.

All framing lumber, as purlins, rafters, joists, etc., to be of good quality, mill-sawed, square-edged, straight, sound, dry, yellow or white pine lumber, free from loose knots, rot, or any imperfections that will impair its usefulness or strength.

All purlins to be spaced and secured as shown on drawings and to be notched into main rafters. All purlins forming one string to be scarfed together above rafters and to have one $\frac{3}{4}$-inch screw bolt going through both pieces. Washers to be under heads and nuts. All connections to be made as shown, and all ironwork, as shoes, bolts, angles, anchors, straps, nails, etc., required in roof construction to be furnished by the contractor. Nails for spiking purlins to rafters to be not less than 3 inches long.

Where purlins terminate at walls they must be securely anchored to walls every 6 feet.

The above quantities are approximate, and the commanding officer reserves the right to increase or altogether omit any item as may be deemed advisable in his judgment.

The bidder will state name of pipe and brand of cement he proposes to use on the work.

The sewers and drains are to be laid in such locations and upon such lines and grades as the commanding officer shall designate.

All the pipes, bricks, jute, sand, and cement, manhole and catch-basin castings will be furnished by the contractor.

The contractor shall be held responsible for any loss incurred or damage done to pipes or materials from the time of delivery until laid and covered.

No pipe shall be laid or used which is known or may be found to be defective. Notice shall always be given to the commanding officer of any defective or imperfect material, and it shall be set aside and marked. If any defective pipe shall have been found to have been laid it shall be removed and replaced by sound and unobjectionable pipe at the contractor's expense.

## *Trenches.*

Trenches for sewers and drains shall be opened in accordance with the lines and grades given for the work, and as far in advance of the construction as may be required by the commanding officer, but no further.

The paving, gravel, macadamizing, or other surface material shall be carefully taken off and put on one side of the trench; the remaining excavation shall be put upon the other side of the trench, so that there shall be no waste of material, and in such manner as to leave two (2) feet between the edge of the trench and the material so deposited.

The earth is to be compactly placed along the trench so as to be of as little annoyance as possible, and a passage left for vehicles, so far as practicable, and no obstruction shall be placed upon the sidewalks. Earth and all material shall be so placed that free access may be had at any time to all hydrants and water gates.

All surplus earth and other material from the excavation shall be removed and disposed of at the expense of the contractor, unless claimed by the commanding officer.

Where rock is encountered it shall be taken out to a depth of six (6) inches below the under side of pipe.

In the sewer the excavation so made shall be refilled from the bottom of the trench to two (2) feet above the sewer, with earth free from stone, or such material as shall be approved by the commanding officer, in thin layers and properly and thoroughly rammed.

In the drain the trench shall be refilled to within eighteen (18) inches of the surface with suitable stone found on the work, on top of which an inverted sod shall be placed, and the remainder refilled with earth.

The contractor is solely responsible for all damages or injuries to persons, structures, or property caused by blasting or otherwise, or from neglect in not properly guarding the trenches.

### PIPE-LAYING.

All sewer pipe and branches are to be laid with joints close butted, well filled with mortar, and scraped clean inside after laying, and not bearing upon the sleeves.

Before filling the joints with mortar a narrow gasket of clean and sound jute shall be introduced and properly and tightly calked so as to leave sufficient depth for the mortar; the mortar shall not be used until the inspector has pronounced the packing and depth to be satisfactory. The drain pipe shall be laid with loose joints.

Before lowering pipes and branches into the trench they shall first be properly fitted together on the surface of the ground in the order and position in which they are to be finally laid.

Every open end of a sewer or drain shall be securely closed before leaving the work at any time.

### MANHOLES.

Manholes will be four (4) feet in diameter inside at the middle of the sewer, or of such other dimensions as the commanding officer shall direct; to diminish to two (2) feet in diameter eight (8) inches below the grade of the ground, and to be capped with a cast-iron frame and cover, in accordance with the plans. The brickwork is to be eight (8) inches thick throughout and is to be plastered on the outside with Rosendale cement. Steps will be built in each man-hole, to be of brick or iron, as the commanding officer shall direct.

All slates to be nailed on with two 4d copper flat-head slate nails to each slate. The ridges to have a galvanized-iron (No. 24) ridge roll. Roll to be 4 inches, with an 8-inch apron on each side, which is to be turned down over edges of ridge board, and securely nailed to said edges. All valleys to be of tin, not less than 20 inches wide, painted on both sides with two coats of metallic paint before laying them on building. Top course of slate on all ridges and 1 foot on each side of all valleys to be laid in oil cement. All flashings about walls projecting above roofs (including walls of gun shops) to be of zinc. All flashings about walls, etc., to be counterflashed and cemented into joints of brickwork.

All roofs to be covered with 3-ply tarred roofing felt, laid to lap at least 2 inches, and to be well tacked down before laying on slate. Contractor is to put under all tin one thickness of the heaviest red rosin-sized paper before laying tin.

All tin to be used to be "old style" brand roofing tin, in sheets 14 by 20 inches, well nailed down, and soldered heavy with strictly half-and-half solder.

On completion of all work the roofs will be inspected and must be found in perfect condition. All work must be done in a good workmanlike and proper manner throughout, and roofs warranted for one year.

### WATER-CLOSET.

The interior arrangement of the water-closet is shown on the plans. It contains ten water-closets on one side and nine urinals on the other. The water-closets are arranged in three groups: one comprising two closets in the small room to the south, and two groups of four closets each in the larger room. The small room has a corner urinal, while the larger room is to contain two groups each of four urinals.

The water-closets must be of the type and make as shown on plate 345 G, page 147, of the J. L. Mott Iron Works illustrated catalogue.

The hopper to be of porcelain, with double-acting valve, black walnut seat 24 inches square, with painted iron legs, and enameled cast-iron slope safe. The double-acting valve gives a preliminary wash when seat is depressed, and the main wash when seat is relieved.

The valve is to be placed not less than 3 feet below the floor, away from the frost. A rod of suitable length to be attached between valve and seat to properly operate the closet. The drip pipe will allow the water in supply pipe between valve and hopper to pass out. The distance between centers of water-closets is to be 30 inches. Each closet is to be inclosed, the inclosures to be of ample size. The sides of said inclosures to be of 1-inch white pine boards, tongued and grooved, and framed in a neat, plain, and substantial manner. Each closet is to have a slat door in front, swinging in hinges and provided with a spiral doorspring. Said inclosures must be 6 feet 6 inches high from the floor and are to rest on iron legs. No wooden part of the inclosures must approach the floor closer than 12 inches. Each closet is to be provided with two bronzed hat hooks. All woodwork of the inclosures is to be painted the same color as the seats of the closets.

Foundation bolts for securing all iron legs must be furnished and set by the contractor before the concrete floor is made.

A cast-iron sewer pipe of 6 inches diameter with ten tees must be located under the floor beneath the water-closets, and the hoppers and traps must be properly connected to same. Suitable connections to this pipe must be made, also, from the urinals, and such connections must be properly trapped. This sewer pipe is to be properly drained and ventilated, and is to leave the building at a depth of not less than 4 feet below the ground line. It must first lead east to a manhole 18 feet distant from the wall of the small gun shop. The vault for sewer pipe below floor must also be ventilated. The sewer pipe and manhole must be made in accordance with directions from the commanding officer.

All urinals are to have slate slabs on the floor in the same plane with the latter and properly pitched. At the end of these bottom slabs will be provided a slate gutter along the wall, and the walls in front and on each side of urinals are to be lined with slate slabs.

The urinals in large room must be subdivided by slate slabs. All this work must be done in a neat and most thorough manner, and all floor slabs and the gutter must be laid in neat cement and must be properly drained. The slotted flush pipes for urinals in large room are to be carried along the slate lining in front at a height of about 4 feet above the floor line, passing through the slate partitions. They must be of brass, 1¼ inches in diameter, and must have a sawed split along the bottom of such nature as to discharge water properly and uniformly for the entire length. Each flush pipe must be provided with a 1¼-inch stop valve. The corner urinal in the small room is to be of porcelain, properly secured to the slate slabs of the corner lining. A 3-inch water pipe will be provided by the Ordnance Department at a distance of about 18 feet from the small gun shop and parallel to same, with a nozzle opposite water-closets. Contractor is to make connections at be on record, and any damage done or caused by act or neglect on his part is to be paid for by the contractor.

In all cases where necessary to prevent the caving in of the bank the contractor must furnish and put in suitable bracing materials and remove the same as the trenches are filled, without charge therefor. He shall also furnish lumber for grade boards, and set all that are necessary for the same without additional charge.

The contractor shall during the nighttime put up and maintain such barriers and red lights as will effectually prevent the happening of any accident in consequence of his work, as he will be solely liable for all damages caused by any neglect on his part or that of his employés.

In covering the sewers the best earth from the trench, entirely free from stones, shall be carefully rammed around the sewer, and the remainder placed upon the sewers in layers of not more than two (2) feet, and thoroughly rammed or puddled.

In covering the drains the trench shall be refilled to within eighteen (18) inches of the surface with suitable stone found on the work, on top of which an inverted sod shall be placed, and the remainder refilled with earth.

The sewer-trenches shall be refilled with the materials furnished from their excavation, provided it be of proper quality, but in case sufficient suitable material is not obtained in this way, that which is suitable shall be furnished by the contractor, and he shall remove or uniformly spread over the surface all material not used in filling.

In all cases where required, the class of surface before existing shall be replaced so as to be in every way equal to that surface in material and workmanship and satisfactory to the commanding officer.

The back-filling and removal of materials shall follow closely upon the completion of the sewer, and in case of neglect or delay to do this work, the commanding officer may, after one day's notice, do the work and deduct the cost from any payment due the contractor.

Any unfaithful or imperfect work that may be discovered before the final acceptance of the work shall be corrected immediately upon the requirement of the commanding officer, notwithstanding that it may have been overlooked and estimated. The inspection of the work shall not relieve the contractor of any of his obligations to perform sound and reliable work as herein described.

The contractor shall keep the work in repair until after final payment, and shall correct and repair promptly during that time all leaks and failures of whatever description and all settlements or irregularities of paving or other surfacing, and any imperfect work upon sewers, drains, or other structures, and shall deliver the work in all respects in good condition at the end of that time.

In all operations connected with the work herein specified, all existing ordinances, and all laws and regulations, controlling or limiting in any way the actions of those engaged on the work, or affecting the materials applied to them, must be respected and strictly attended to.

All direction and instruction will be given by the commanding officer of the Watervliet Arsenal, or his authorized assistants, and he shall have it in his power to make such changes in the forms, dimensions, grades, and alignments of the work as the interests of the arsenal shall seem to require. Any increased cost resulting therefrom shall be paid at the price provided for in the contract for each class of work.

All grades, locations, dimensions, and heights will be given by proper stakes and bench-marks. Such stakes and bench-marks must be preserved by the contractor until the prosecution of the work requires their removal. If the contractor in a willful and careless manner removes, or causes the removal, of any of the said stakes or bench-marks, before the prosecution of the work requires it, the expense of replacing them will be charged the contractor, and the amount deducted from the amount due on his final settlement.

The commanding officer will make all measurements and decide as to the amount or quality of the several kinds of work, and as to the quality of the materials. All work and all material shall be subject to his approval.

The commanding officer shall also decide as to the meaning or intent of any portion of these specifications, where the same may be found obscure, and he shall have the right to correct any errors and omissions in them. Where corrections are necessary for the proper fulfillment of their intention, the action of such correction is to date from the time that the commanding officer gives notice thereof.

No claims for extra work shall be allowed, unless the same shall have been in pursuance of a written order from the commanding officer. All claims for extra work so ordered must be made to the commanding officer, in writing, before the payment of the next succeeding estimate, after the work was performed, and failing to make such claim, the same shall be considered as abandoned by the contractor.

The contractor shall employ competent foremen and experienced mechanics, and others skilled in the several parts that are given them to do; and shall immediately discharge, when required to do so by the commanding officer, any incompetent man or anyone disposed to be disorderly.

Payments will be made by the commanding officer at the request of the contractor; but not oftener than once a month.

It is expressly understood that such estimates shall only be made when the work progresses as rapidly as may be required by the commanding officer, and in accordance with the provisions of the contract.

The estimates exhibited at this date are only approximate; and no claims growing out of the misconception of the quantities of the kinds of work, or of any error in the approximate statement of them at this date, are to be allowed or considered valid.

The work shall be begun and carried on at such points, and in such order of precedence, and at such times and season, as may from time to time be directed by the commanding officer.

Bids are required for the work divided into classes as follows, viz:

I. For all earth excavation in sewer-trenches, including excavation for manholes, and other structures appertaining to the sewer, and the disposal of material and refilling of trenches (rolling, ramming, and watering where required), including sheeting and shoring, bridging and fencing, and removal of the same; all protection and restoration of buildings, fences, existing sewers, cisterns, water-pipes, house-drains, etc.; all resurfacing and repaving of roads and all other incidental work; the trenches to be measured three (3) feet in width for all sizes of pipe, the sum of ——— cents (——— cents) per cubic yard.

II. For all earth excavation in drain-trenches, including excavation for manholes, catch-basins, and other structures appertaining to the drain, and the disposal of material and refilling of trenches, including sheeting and shoring, bridging and fencing, and removal of the same; all protection and restoration of buildings, fences, existing sewers and drains, cisterns, water-pipes, house-drains, etc.; all resurfacing and repaving of roads and all other incidental work; the trench to be measured three (3) feet in width for all sizes of pipe, the sum of ——— cents (——— cents) per cubic yard.

III. For all rock excavation in sewer-trenches, including excavation for manholes and other structures appertaining to the sewers, and disposal of materials and refilling of trenches, including sheeting and shoring, bridging and fencing, and removal of the same; all pumping or bailing or otherwise disposing of water; all protection or restoration of buildings, fences, existing sewers or drains, cisterns, water-pipes, etc.; all resurfacing and repaving of roads and all other incidental work; the trenches to be measured three (3) feet in width for all sizes of pipe, the sum of ——— per cubic yard.

IV. For all rock excavation in drain trenches, including excavation for manholes, catch-basins, and other structures appertaining to the drains, and disposal of materials or refilling of trenches, including sheeting and shoring, bridging and fencing, and removal of the same; all pumping and bailing or otherwise disposing of the water; all protection or restoration of buildings, fences, existing sewers or drains, cisterns, water-pipes, etc.; all resurfacing or repaving of roads and all other incidental work; the trenches to be measured three (3) feet in width for all sizes of pipe, the sum of ——— per cubic yard.

V. For laying sewer-pipe, including branches or inlets, furnishing all tools and all materials, and doing all labor incidental thereto, the lengths to be measured along the center of the pipe as laid, the following prices for the various sizes:

For 10-inch, the sum of ——— per linear foot.
For 8-inch, the sum of ——— per linear foot.
For 6-inch, the sum of ——— per linear foot.
For 4-inch, the sum of ——— per linear foot.

VI. For laying drain-pipe, including branches and inlets, furnishing all tools and all materials, and doing all labor incidental thereto, the lengths to be measured along the center of the pipe as laid, the following prices for the various sizes:

For 10-inch, the sum of ——— per linear foot.
For 8-inch, the sum of ——— per linear foot.
For 6-inch, the sum of ——— per linear foot.

VII. For laying all manholes complete, furnishing the cast-iron covers, bricks, sand, and cement, the sum of ——— dollars each.

VIII. For laying up all catch-basins complete, furnishing the cast-iron covers and traps, bricks, sand, and cement, the sum of ——— dollars ($———) each.

IX. For doing any and all work not included in these specifications under the above items, the various prices set against the several items as follows:

Laborers, ——— per day.
Single teams and drivers, ——— per day.
Double teams and drivers, ——— per day.
First-class masons, ——— per day.
Helpers, ——— per day.

Foremen, ——— per day.
Ledgemen, ——— per day.

Bidders will state time at which the entire work will be completed by them. A penalty of $20.00 will be exacted for each and every day of delay beyond the date of completion of the whole work.

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### *Specifications for the construction of roads at the Watervliet Arsenal, West Troy, N. Y.*

The roads to be constructed and paved are shown on the accompanying map. As regards their width, the wording of these specifications takes precedence over the dimensions figured in drawings. Such width may be increased or diminished at the option of the commanding officer. The grade of all roads will follow, as much as possible, the natural grade of the grounds.

Grade stakes and line stakes will be furnished and set by the Department.

The top level of existing paved roads will be retained in the new roads, except where otherwise directed by the commanding officer, who may also change the lines of roads, if this should be, in his judgment, preferable.

The crown of all macadam roads is intended to be about 6 inches, but such crown will be determined by the commanding officer for each individual road, and before execution the contractor will ask for proper directions in this respect.

Any gravel necessary for the work, in conformity with these specifications, will be furnished, unscreened, along the Hudson River dock, by the Department.

All flagging required, as specified, will also be furnished by the Department at the line of work where such flagging will be needed.

All other materials, also all labor of any kind, and all tools and appliances required for the proper prosecution of the work, must be furnished by the contractor.

All excavated material that is left along the line of the work after its completion will be removed by the Ordnance Department.

The following are the approximate quantities of the work to be done:

| | |
|---|---|
| Granite roads and pavements | 1,700 square yards. |
| Macadam roads and pavements | 5,000 square yards. |
| Flagging laid | 2,300 square feet. |

The amount of work to be done may be increased or diminished at the discretion of the commanding officer, in view of the funds available for the purpose.

Bids will be received as follows:

1. Price per cubic yard of earth excavation.
2. Price per cubic yard of rock excavation.
3. Price per square yard of macadam road, on rock bottom.
4. Price per square yard of macadam road, on earth bottom.
5. Price per square yard of granite pavement.
6. Price per square foot of flagging laid.
7. Price per square foot of paved gutter.

The excavations for macadam roads and pavements will be paid for at the rate given in items 1 and 2.

The cost of all excavation necessary for the construction of granite-block roads and pavements shall be included in the price paid for the pavement.

Loose or surface shale will be paid for at the price stated in item 1; the price in item 2 is for excavation of solid rock only.

In doubtful cases the decision of the commanding officer will be final.

Payment will be made upon the completion of the whole work, or, at the request of the contractor, in two installments of 50 per centum each. No payment will be made for more than the full value of the amount of the work done by the contractor.

The time for the completion of the whole work will be stated in the bid. A penalty of $10 will be exacted for each and every day of delay beyond the time stated in the contract for the completion of the whole work.

#### MACADAM ROADS AND PAVEMENTS.

All roads designated A on the map are to have macadam pavement. Most of these roads run over rock ground, while some of them will be made on a substantial earth soil.

All macadam roads will be 16 feet wide, except where otherwise figured on the plan.

All such roads whose grade or location does not permit drainage without gutters must be provided with stone gutters, 18 inches wide, on one or on both sides of the road, as noted on the map. Said gutters must have such depths as to drain the roads

3 blocks, 20 inches by 8 inches by 2 inches.
1 block, double, for 15-inch shears.
1 block, single, for 15-inch shears.
1 block, snatchwood, for 5½-inch rope.
40 chocks, roller.
40 chocks, wheel.
20 chocks, gun.
20 chocks, 15-inch gun.
1 cap shears.
1 cradle for 8-inch and 10-inch guns.
6 floor boards for 8-inch Rodman gun carriage sets.
1 gin, garrison.
3 handspikes, gin.
1 platform for 4½-inch rifle.
10 platforms for siege guns.
4 platforms for 8-inch and 10-inch siege mortars.
10 platforms for siege mortars.
6 rollers, short.
6 rollers, 2-inch.
18 rollers, 5-inch.
18 rollers, 6-inch.
18 rollers, 7-inch.
6 rollers, oak, 8 inches diameter, 4 feet long.
6 rollers, oak, 8 inches diameter, 3 feet long.
18 rollers, cradle.
2 skids, oak, 96 inches by 12 inches by 12 inches.
12 traveling planks, 16 feet by 10 inches by 2 inches.
48 way planks.

## CLASS 10.

### PARTS APPERTAINING TO CLASS 1.

1 De Bange obturator.
1 De Bange obturator pad. } For 3.2-inch B. L. rifle.
6 Freyre obturators.
2 Freyre obturator gas-check rings.
2 gas-check pads, for 7-inch B. L. howitzer.
30 gas-check pads, for 12-inch cast-iron mortar, hooped.
1 gas-check pad, for 10-inch W. W. rifle, C. I.

### PARTS APPERTAINING TO CLASS 2.

2 ammunition chests for limbers, 3.2-inch rifle.
4 braces, metallic, for lid of ammunition chest.
3 bronze screw lids for primer box.
5 canvas covers for ammunition chests, 3.2-inch rifle.
12 corrugated plates, 3.2-inch limbers.
4 cap squares. } For 3.2-inch limbers.
2 double trees, special pattern.
1 double and 2 single trees, steel.
8 doubletrees.
17 singletrees.
40 linchpins.
46 linch washers. } For 3.2-inch limbers.
13 neck-yokes.
3 poles, spare.
2 poles, not ironed.
4 pole-props for end of pole.
2 pole-prop springs and hooks.
5 road-brakes for caisson 3.2-inch gun, pairs.
1 road-brake for battery-wagon, pair.
1 stay-pin and chain for ammunition chest.
5 spring clasps for handspikes, maneuvering, 3.2-inch.

### PARTS APPERTAINING TO CLASS 3.

2 breast straps for double harness, pairs.
140 breast-strap hooks.
132 back-strap hooks and D-rings.

### EXCAVATIONS AND GRADING.

As much of the excavated material from trenches as will be required for refilling will be deposited alongside of the trenches; the remainder is to be used in filling up the grounds inside of wash room and water-closets.

After the walls are above ground the trenches must be refilled and solidly rammed around walls by the contractor. He is also to grade the grounds around outside of the building for a distance of 6 feet. All ground lines around building must slope away from walls, as shown, and the ground must be tightly rammed. A gutter paved with stone must be made along the west side of the building, and is to be properly drained.

### CONCRETE.

The foundations of all walls will be laid on a bed of concrete at the bottom of the excavations. The depth and all other dimensions of concrete beds are shown in drawings. The concrete shall be formed of sound broken stone, not exceeding 2 inches at their greatest diameter, and of a quality approved by the commanding officer. All stone in any way larger is to be thrown out. The sand to be used must be of coarse grain, clean and sharp, and free from loam.

The cement must be equal in quality to the best Rosendale cement; it must be fresh and very fine ground, and in well-made and lined casks. The tensile strength of a specimen, 24 hours after molding, air-dry, must not be less than 80 pounds per square inch of section. The cement will be subject to inspection and tests, and if found of improper quality will be branded, and must be immediately removed from the site. The materials for concrete must be cleaned from dirt and dust before using; they must be mixed dry in proper boxes in the following proportion: One part by measure of cement to two parts of sand and five parts of broken stone. The sand will be put in the box first and spread out; the cement will be spread over the sand then, and both will be turned over three times to assure a uniform mixture. The stone having been well wetted is next added, and all ingredients are turned over twice with shovels, adding a moderate quantity of water to produce a mixture of proper consistency. The mixing is to be done near the place of laying, the concrete to be laid, immediately after mixing, into wetted ground, and to be thoroughly compacted with heavy tampers till the water flushes to the surface. The concrete shall be allowed to set for about twenty-four hours before any work shall be laid upon it. No walking over or working upon it shall be allowed while it is setting.

The floor of the wash room will be made of concrete, 6 inches thick, laid on well-rammed ground, evenly up to within 1 inch of the floor line. The top of such concrete is to be flushed off with a coat of cement 1 inch thick. The whole floor must have a pitch of 1 inch on all sides toward the drain. Where foundation bolts for the supports of the sinks are located they must be set in place by the contractor for the plumbing work before the concrete is laid.

Wherever the ground should be lower than required for the concrete the contractor will fill up with material which will be furnished by the Department at the building site; ram well and grout with a mixture of one part cement to two parts sand to make the ground compact.

The concrete floor of the water-closet is to be prepared in the same manner as the floor of the wash room, but instead of a coat of cement it will receive a coat 1 inch thick of best Swiss (Neufchatel) asphalt. Care must be taken to give this floor a slight pitch toward the urinals. This asphalt floor can not be made until the installation of water-closets and urinals is complete.

### MASONRY WORK.

All brick masonry in walls, piers, vault, and drains is to be furnished as shown on plans. The brick masonry is to commence on a bed of concrete. All brickwork below the floor line is to be laid in best hydraulic cement and rock-lime mortar, mixed in the proportion of one part cement, one-half part lime, and two parts sand, properly mixed, as much at a time as can be used before setting; no cement mortar to be used after it had been once set. Said cement mortar is to be used to a height in level with the floor line of the building, at which point the last course shall be evenly and smoothly pargetted over with cement, forming a damp proof course, before remainder of brickwork is started.

The bricks will be furnished by the Ordnance Department at the site of the building. No bats shall be used without the permission of the commanding officer, but nothing smaller than half bricks.

All brickwork above the floor line is to be laid in mortar made of domestic cement of approved quality, best hydraulic rock lime, and clean, sharp sand of coarse grain, in the following proportions: One-half part of cement to one part of lime, and two parts of sand. The mortar to be well and thoroughly mixed. No air-slaked lime to be used. The bricks to be thoroughly wetted before laying, except when otherwise ordered by the commanding officer. Every brick to be completely imbedded in mortar. Care shall be taken to have every joint full of mortar. Competent mechanics shall be employed for this work. All bricks shall be laid close, straight, and plumb, well flushed in and properly bonded with one course of headers to every six courses in height. All joints on exterior of walls to be neatly pointed with black mortar and flush on interior.

Facing brick to be of uniform color, as much as possible. Brick arches to be turned over all doors and windows (except transom windows) and other openings, as shown on plans. All arches to be double, 8 inches thick, except where shown otherwise.

Contractors will furnish and set in place all window and door sills, and the water table around walls of wash room and offices. Walls on either side of passage and walls of passage to have no water table. All sills and water table to be of North River blue stone, free from any defects, and similar in appearance and finish to those of the new gun-factory building. All sills to be made in one single piece, and to be 2 inches longer on each end than width of door and window frames. All window sills and water table to be 8 inches wide by 5 inches thick; all door sills to be 18 inches wide by 5 inches thick, and to be provided with mortices for door-jambs. All sills and water table to have proper wash. No stone sills are required for interior doors and windows. All stones to be cut to exact dimensions, and all angles and arrises shall be true and well defined. All beds and builds shall be dressed for the full width of the stone. All cut stone to lie on its natural bed and to be well bedded in pure domestic cement of approved quality. All anchors for securing roofs to walls, also all other anchors required for the completion of the building, will be built in by the contractor.

The top of all walls to be covered over with a coat of cement mortar. The walls of the passage must be tied into walls of shop buildings.

All gable walls to be anchored to purlins of roofs at intervals of 6 feet by wrought-iron anchors 2 x ⅜ inch, built into walls. All anchors and bolts to be furnished by the contractor for the carpenter work.

All cornices are to be of brickwork, and to be built as shown in elevations and details. They must be well bonded and neatly built and painted up. The contractor is to cut out or build up after carpenters, roofers, plumbers, or other contractors everything necessary to complete the building.

The contractor is to clear the building and site from all refuse and rubbish, to do all refilling and grading about the walls, and to leave in neat condition the grounds occupied by him. He is to give all facilities to other contractors for performing work adjoining his own, and any difference which may arise between two contractors in regard to their adjoining work is to be adjusted by the commanding officer. His decision is to be final in the matter. The mason work must be prosecuted uniformly and steadily, and no part of any wall shall at any time rise more than 3 feet above the rest. All unfinished work must be raked back, as may be directed by the commanding officer in each case, and before new work is joined to its surface the bricks must be scraped clean, scrubbed with a stiff brush, and well moistened.

All interior surfaces of walls above floor line to receive two heavy coats of whitewash after the building is under roof.

### CARPENTER WORK.

The carpenter work comprises all work on roofs, except tinning and slating, on the floors and ceilings of office rooms and passage between them, on the covered way leading to and around water-closet, and all windows and doors. The lumber for the wooden floors in passage between shops and the clothes closets in wash rooms will be provided by the Ordnance Department. The contractor has to lay the floor in passage.

All framing lumber, as purlins, rafters, joists, etc., to be of good quality, mill-sawed, square-edged, straight, sound, dry, yellow or white pine lumber, free from loose knots, rot, or any imperfections that will impair its usefulness or strength.

All purlins to be spaced and secured as shown on drawings and to be notched into main rafters. All purlins forming one string to be scarfed together above rafters and to have one ⅝-inch screw bolt going through both pieces. Washers to be under heads and nuts. All connections to be made as shown, and all ironwork, as shoes, bolts, angles, anchors, straps, nails, etc., required in roof construction to be furnished by the contractor. Nails for spiking purlins to rafters to be not less than 3 inches long.

Where purlins terminate at walls they must be securely anchored to walls every 6 feet.

All roofs to be covered with sound 1-inch white-pine boards, tongued and grooved, averaging 8 to 10 inches in width, driven up close and nailed to each purlin through each edge and center. Said roofing to be dressed on one side to a uniform thickness after being laid. All framing on and around skylight to be done as shown. Flooring of office rooms and covered ways to be of 1½-inch yellow pine. All wooden posts to be neatly chamfered. Ceiling in office rooms and passage between to have ceiling joists of 6 by 2 inch good, sound, white pine or spruce, to be laid on wall plates, sheeting to be of tongued and grooved, secret nailed, yellow-pine boards ⅞-inch thick. Ridge boards 8 by 1½ inches, to be on ridges of all roofs.

Wall plates to be 8 by 3 inches; truss beams to be 8 by 10 inches; truss rafters to be 8 by 10 inches; struts to be 8 by 6 inches; purlins to be 6 by 6 inches, and common rafters to be 6 by 2 inches. Dimensions of lumber in roofs of passage, covered way, and water-closet, also in floors, as shown on drawings. All common rafters to be spaced about 20 inches between centers. Boards around eaves to finish as shown on detail drawing.

The floors of offices to be made as follows: Joists of 6 by 6 inch spruce or yellow pine, to be laid at the proper level, 24 inches between centers, and the ground below them to be filled up and tamped to form a firm bearing for the joists. Single flooring to be of 1½-inch narrow width, tongued and grooved, bright yellow pine, secret nailed.

All window frames and sashes to be of sizes figured and shown on drawings. All exposed woodwork to be made of sound, kiln-dry, yellow or white pine, neatly dressed. All sashes to be sliding, except those in east and west walls of water-closet and wash room, which will be swinging. Sashes to be of heart white pine. Check rails to be plowed and bored for chords. All glass to be single and of good quality; sizes are given in drawings.

All sliding sashes to be double hung with 2½-inch Excelsior (or equal) axle pulleys and Silver Lake sash cord No. 8, and to be properly balanced with lead or iron weights.

All swinging sashes to have stout swivels, fastened on inside of sash, and transom lifters or other proper arrangements for holding windows open and closed, and for operating them from the floor. Galvanized-iron flashings to be on outside of bottom rail to drain off the water.

All window frames to be properly fastened in walls. All window frames must be ready, and must be set in place by the contractor as soon as window sills are set, so as not to cause any delay in the erection of the brick walls.

All door frames and doors to be of sizes shown on drawings. All exposed woodwork to be of sound, clear, well-seasoned, dry, yellow, or white pine lumber. Wooden door frames to be well anchored to brickwork with light iron anchors, three or four to each jamb, ends to be doweled to sills. Door frames to be 2½ inches thick; width of frames to be full thickness of wall.

The doors to be of heart white pine, four panels, 1⅝ inches thick, double molded. Upper panels to be glazed with ground glass in doors of office rooms, and with common glass in all other doors. Doors to be hung in broad, loose joints, wrought-iron butts and hinges. Both doors of wash room to have stout bolts, top and bottom, square spring pattern, appropriate to size and kind of door. Patterns and sizes to be approved by the commanding officer.

Office doors to have mortise locks, bronze knobs, and triplicate steel keys. All other doors to have rim locks with triplicate keys, and stout wrought-iron handles and latches on both sides, all of approved sizes, quality, and pattern. All door frames to be set in place by the contractor in time for the mason to build them into brickwork. All doors and windows must be complete in all respects. All window and door frames and sashes to be primed with a coat of white-oil paint before being delivered on the premises.

The contractor has to furnish all screw bolts, screws, anchors, spikes, nails, etc., required for the execution of his contract. He is also to furnish all necessary centers for arched openings, and perform any other carpenter work that may come in his line.

### PAINTING.

All window frames and sashes, also all door frames and doors must be painted on the inside and outside with two coats of dark red paint, made up with linseed oil. Color to correspond with that of the windows and doors of new gun-factory building. Ceilings of office rooms to be oiled.

### ROOFING AND TINNING.

All roofs to be covered with No. 1 Chapman slates, or equal, size 8 by 16 inches or 10 by 18 inches. Slates to be strong and heavy, and to be laid 6½ inches to the weather. Bidder to furnish a sample slate on which his bid is based.

All slates to be nailed on with two 4d copper flat-head slate nails to each slate. The ridges to have a galvanized-iron (No. 24) ridge roll. Roll to be 4 inches, with an 8-inch apron on each side, which is to be turned down over edges of ridge board, and securely nailed to said edges. All valleys to be of tin, not less than 20 inches wide, painted on both sides with two coats of metallic paint before laying them on building. Top course of slate on all ridges and 1 foot on each side of all valleys to be laid in oil cement. All flashings about walls projecting above roofs (including walls of gun shops) to be of zinc. All flashings about walls, etc., to be counter-flashed and cemented into joints of brickwork.

All roofs to be covered with 3-ply tarred roofing felt, laid to lap at least 2 inches, and to be well tacked down before laying on slate. Contractor is to put under all tin one thickness of the heaviest red rosin-sized paper before laying tin.

All tin to be used to be "old style" brand roofing tin, in sheets 14 by 20 inches, well nailed down, and soldered heavy with strictly half-and-half solder.

On completion of all work the roofs will be inspected and must be found in perfect condition. All work must be done in a good workmanlike and proper manner throughout, and roofs warranted for one year.

## WATER-CLOSET.

The interior arrangement of the water-closet is shown on the plans. It contains ten water-closets on one side and nine urinals on the other. The water-closets are arranged in three groups: one comprising two closets in the small room to the south, and two groups of four closets each in the larger room. The small room has a corner urinal, while the larger room is to contain two groups each of four urinals.

The water-closets must be of the type and make as shown on plate 345 G, page 147, of the J. L. Mott Iron Works illustrated catalogue.

The hopper to be of porcelain, with double-acting valve, black walnut seat 24 inches square, with painted iron legs, and enameled cast-iron slope safe. The double-acting valve gives a preliminary wash when seat is depressed, and the main wash when seat is relieved.

The valve is to be placed not less than 3 feet below the floor, away from the frost. A rod of suitable length to be attached between valve and seat to properly operate the closet. The drip pipe will allow the water in supply pipe between valve and hopper to pass out. The distance between centers of water-closets is to be 30 inches. Each closet is to be inclosed, the inclosures to be of ample size. The sides of said inclosures to be of 1-inch white pine boards, tongued and grooved, and framed in a neat, plain, and substantial manner. Each closet is to have a slat door in front, swinging in hinges and provided with a spiral doorspring. Said inclosures must be 6 feet 6 inches high from the floor and are to rest on iron legs. No wooden part of the inclosures must approach the floor closer than 12 inches. Each closet is to be provided with two bronzed hat hooks. All woodwork of the inclosures is to be painted the same color as the seats of the closets.

Foundation bolts for securing all iron legs must be furnished and set by the contractor before the concrete floor is made.

A cast-iron sewer pipe of 6 inches diameter with ten tees must be located under the floor beneath the water-closets, and the hoppers and traps must be properly connected to same. Suitable connections to this pipe must be made, also, from the urinals, and such connections must be properly trapped. This sewer pipe is to be properly drained and ventilated, and is to leave the building at a depth of not less than 4 feet below the ground line. It must first lead east to a manhole 18 feet distant from the wall of the small gun shop. The vault for sewer pipe below floor must also be ventilated. The sewer pipe and manhole must be made in accordance with directions from the commanding officer.

All urinals are to have slate slabs on the floor in the same plane with the latter and properly pitched. At the end of these bottom slabs will be provided a slate gutter along the wall, and the walls in front and on each side of urinals are to be lined with slate slabs.

The urinals in large room must be subdivided by slate slabs. All this work must be done in a neat and most thorough manner, and all floor slabs and the gutter must be laid in neat cement and must be properly drained. The slotted flush pipes for urinals in large room are to be carried along the slate lining in front at a height of about 4 feet above the floor line, passing through the slate partitions. They must be of brass, 1¼ inches in diameter, and must have a sawed split along the bottom of such nature as to discharge water properly and uniformly for the entire length. Each flush pipe must be provided with a 1¼-inch stop valve. The corner urinal in the small room is to be of porcelain, properly secured to the slate slabs of the corner lining. A 3-inch water pipe will be provided by the Ordnance Department at a distance of about 18 feet from the small gun shop and parallel to same, with a nozzle opposite water-closets. Contractor is to make connections at

All roofs to be covered with sound 1-inch white-pine boards, tongued and grooved, averaging 8 to 10 inches in width, driven up close and nailed to each purlin through each edge and center. Said roofing to be dressed on one side to a uniform thickness after being laid. All framing on and around skylight to be done as shown. Flooring of office rooms and covered ways to be of 1¼-inch yellow pine. All wooden posts to be neatly chamfered. Ceiling in office rooms and passage between to have ceiling joists of 6 by 2 inch good, sound, white pine or spruce, to be laid on wall plates, sheeting to be of tongued and grooved, secret nailed, yellow-pine boards ⅞-inch thick. Ridge boards 8 by 1¼ inches, to be on ridges of all roofs.

Wall plates to be 8 by 3 inches; truss beams to be 8 by 10 inches; truss rafters to be 8 by 10 inches; struts to be 8 by 6 inches; purlins to be 6 by 6 inches, and common rafters to be 6 by 2 inches. Dimensions of lumber in roofs of passage, covered way, and water-closet, also in floors, as shown on drawings. All common rafters to be spaced about 20 inches between centers. Boards around eaves to finish as shown on detail drawing.

The floors of offices to be made as follows: Joists of 6 by 6 inch spruce or yellow pine, to be laid at the proper level, 24 inches between centers, and the ground below them to be filled up and tamped to form a firm bearing for the joists. Single flooring to be of 1¼-inch narrow width, tongued and grooved, bright yellow pine, secret nailed.

All window frames and sashes to be of sizes figured and shown on drawings. All exposed woodwork to be made of sound, kiln-dry, yellow or white pine, neatly dressed. All sashes to be sliding, except those in east and west walls of water-closet and wash room, which will be swinging. Sashes to be of heart white pine. Check rails to be plowed and bored for chords. All glass to be single and of good quality; sizes are given in drawings.

All sliding sashes to be double hung with 2¼-inch Excelsior (or equal) axle pulleys and Silver Lake sash cord No. 8, and to be properly balanced with lead or iron weights.

All swinging sashes to have stout swivels, fastened on inside of sash, and transom lifters or other proper arrangements for holding windows open and closed, and for operating them from the floor. Galvanized-iron flashings to be on outside of bottom rail to drain off the water.

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The contractor has to furnish all screw bolts, screws, anchors, spikes, nails, etc., required for the execution of his contract. He is also to furnish all necessary centers for arched openings, and perform any other carpenter work that may come in his line.

### PAINTING.

All window frames and sashes, also all door frames and doors must be painted on the inside and outside with two coats of dark red paint, made up with linseed oil. Color to correspond with that of the windows and doors of new gun-factory building. Ceilings of office rooms to be oiled.

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Four coils, each 12 feet long, in the passage;

Four coils, each 20 feet long, in the wash room.

All coils must be made of ten 1-inch steam pipes, having manifolds at ends. All coils to be made with necessary provisions to allow for expansion. Each heating coil must be provided with an air valve, a 1¼-inch steam supply, and a 1-inch drip valve. All valves to be readily accessible. All coils in office rooms and in passage must be properly supported and secured to walls by means of wooden battens and hook plates of sheet steel. The lowest pipe of all these coils should be about 12 inches above the floor line. The coils in wash room must be suspended horizontally from the roof trusses at a height of 7 feet 6 inches above the floor line. The pipes of these coils must be properly spaced by an adequate number of ring plates or otherwise, in approved manner. Care must be taken to drain these coils properly.

The steam supply pipe for all coils has 2 inches diameter, and will be connected with the 2-inch steam pipe supplying the heating coils on the west wall of the small gun shop. A 2-inch globe valve is to be interposed at the junction to shut the steam off from wash room, etc., entirely, if desired. The 2-inch steam-supply pipe is to lead into the passage first, and branches are to go to the office rooms and the wash room.

The returns or drips from coils must lead to a steam trap of approved pattern and ample capacity, which must be arranged to allow air and water of condensation to escape from pipes without loss of steam. The trap is to discharge, if possible, into the 3-inch drain or waste pipe from the sinks. All long lines of pipes must be provided with miters arranged to allow for expansion. All parts of the heating plant must be properly dripped.

All pipes must be standard wrought-iron steam pipe; all sizes above 1¼ inches to be lap welded; all fittings to be of cast iron; all valves must be Fairbanks, Jenkins, or Scott disk valves. All materials to be used must be of the best quality.

All cutting in walls and floors for the passage of pipes will be done by the contractor.

The plant is to be furnished complete with steam on.

Bids will be received for the following items:

1. For all work specified under headings: Excavations and grading, concrete and masonry work.

2. Price per 1,000 for furnishing the brick that may not be on hand at arsenal, delivered at building site.

3. For all work specified under heading: Carpenter work (including windows and doors) and painting.

4. For all work specified under headings: Water closet, sinks in wash room, and steam heating arrangement, which includes all plumbing and pipe-fitting.

5. For all work specified under heading: Slating and tinning.

Combined bids will be received also for several or all of the above items.

Bidders will please state the approximate time within which they propose to finish the work.

For any delay in the completion of the entire work beyond the date specified in the contract a penalty will be exacted of fifteen dollars ($15) in the contract price thereof for each and every day (excepting Sundays) after said date, until the completion of the contract.

Should the contractor feel aggrieved at any decision of the commanding officer under these specifications, he shall have the right to appeal to the Chief of Ordnance, U. S. A., and his decision shall be final.

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### *Statement of stores fabricated at Watervliet Arsenal during the fiscal year ended June 30, 1891.*

#### CLASS 1.

| | |
|---|---|
| 25 | 3.2-inch breech-loading rifles, steel. |
| 1 | 12-inch breech-loading rifle, steel, type No. 1. |
| 4 | 12-inch breech-loading mortar, steel, type No. 1. |

#### CLASS 2.

| | |
|---|---|
| 1 | carriage for 3.6-inch B. L. field mortar. |
| 22 | caissons and limbers for 3.2-inch guns. |
| 6 | combined forges and battery wagons. |
| 20 | limbers for machine-gun carriages. |
| 2 | mortar wagons. |

this point for the water supply of water-closets and urinals. The supply pipe must be 1½ inches in diameter, is to enter the building below the ground, and is to be properly connected to all supply pipes for closets and urinals. A 1½-inch brass stopcock is to be placed in the supply pipe before entering the building, and is to be provided with iron box and cover, and a stopcock is to be arranged also in each supply pipe for water-closets and urinals. At a suitable place a 1-inch branch pipe with faucet for 1-inch hose attachment is to be arranged and connected with water supply, to be used for flushing purposes.

All water-closets and urinals must be erected complete in working order, and all water and waste connections must be made to assure their proper function; also all sewer connections. All water pipes, including the 1½-inch main supply pipe, to be of galvanized iron, except where otherwise directed.

### SINKS IN WASH ROOM.

There are to be furnished and erected in complete working order, with water and steam on, ten cast-iron sinks, as shown in plans and detail drawings, and as manufactured by the Pittsburg Locomotive Works. Each sink is 20 feet 4 inches long by 28 inches wide, and is on both ends 8 inches, and in the middle at the discharge column about 9 inches deep, and is made in four pieces with planed joints bolted water-tight together. The sinks are supported on four cast-iron columns, resting on the concrete floor and secured to it by ¾-inch bolts, which must be furnished and set by the contractor in time to be built into the concrete floor.

The sink rests on three of the columns by means of a roller of ⅝-inch round iron, and is transversely secured by means of a ⅞-inch stud. The fourth column forms the discharge pipe of the sink and is bolted to it by five ⅝-inch stud bolts. The sink has an 8-inch aperture in the bottom at this point. The top of the column is bell-shaped, and is provided with a circular perforated plate, which is to be made in halves, each half to be screwed to the seat by a ⅝-inch brass screw. Above this plate is a taper seat, carefully finished so as to fit around the conical part of a cast-iron overflow pipe. This conical overflow pipe is to be lifted off its seat whenever the sink should be emptied.

The bottom of the discharge column has spigot cast on, which fits and is to be tightly calked into the bell of a nozzle of the 3-inch drain pipe. This drain pipe is of cast iron, and has ten nozzles for connection with the ten sinks. It is located directly under the floor, and is to be built into the concrete. After passing the sink at the north end it is to turn in the direction of the 6-inch sewer pipe from water-closets, with which it is to be properly connected by means of a Y-piece.

Secured to the top of sinks by means of flat-iron braces is a 3-inch galvanized iron pipe 19 feet 6 inches long, provided with 12 pairs of downward-curved ⅝-inch galvanized pipes screwed into it. The 3-inch pipe has an incline of ¼ inch from the supply to the rear end. The rear end is closed by means of a cap screw, and a ⅛-inch air cock is tapped into the bottom of the pipe directly in front of this cap. The supply end carries a 3 by 1½ inch reducer, to which are attached the steam and water connections, which must be made as shown in detail on drawings. To the braces supporting the 3-inch pipe is secured a bar of 2 by ⅝ inch flat iron, which carries twelve cast-iron soap trays.

The main water supply for the sinks is to be a 2½-inch galvanized-iron pipe, which must be suspended from the roof trusses along and above the supply end of sinks, or which may be fastened to the west wall of the wash room, below the roof trusses. A ¾-inch branch of galvanized pipe leads from the 2½-inch pipe to each sink, with a ¾-inch globe valve near its end. The 2½-inch supply pipe must lead into the passage and lead along north wall of same and down below the floor, and must be connected below ground with a nozzle of the 3-inch water pipe, which will be provided by the Ordnance Department, at a distance of 18 feet from the small gun shop and parallel to same. In its vertical course the 2½-inch pipe must be provided with a 2½-inch brass stop valve, and at a suitable point with a 1-inch branch and valve.

The steam supply for the sinks will be taken from the 2-inch steam-supply pipe of the heating coils. For this purpose a 1½-inch branch pipe will be taken from a convenient point of the 2-inch steam pipe and a 1½-inch brass globe valve will be interposed at the junction. The 1½-inch pipe will be located near and parallel to the 2½-inch water supply pipe, and ¾-inch branch pipes will lead to each sink, where they must be provided with ¾-inch brass globe valves. All connections on supply ends of sinks must be made as shown in detail drawings. All pipe connections must be steam and water tight.

### STEAM HEATING ARRANGEMENT.

The following coils are to be furnished and properly erected as shown on plans:

Two coils, each 12 feet long, in the two office rooms, one coil in each room;

Four coils, each 12 feet long, in the passage;
Four coils, each 20 feet long, in the wash room.

All coils must be made of ten 1-inch steam pipes, having manifolds at ends. All coils to be made with necessary provisions to allow for expansion. Each heating coil must be provided with an air valve, a 1¼-inch steam supply, and a 1-inch drip valve. All valves to be readily accessible. All coils in office rooms and in passage must be properly supported and secured to walls by means of wooden battens and hook plates of sheet steel. The lowest pipe of all these coils should be about 12 inches above the floor line. The coils in wash room must be suspended horizontally from the roof trusses at a height of 7 feet 6 inches above the floor line. The pipes of these coils must be properly spaced by an adequate number of ring plates or otherwise, in approved manner. Care must be taken to drain these coils properly.

The steam supply pipe for all coils has 2 inches diameter, and will be connected with the 2-inch steam pipe supplying the heating coils on the west wall of the small gun shop. A 2-inch globe valve is to be interposed at the junction to shut the steam off from wash room, etc., entirely, if desired. The 2-inch steam-supply pipe is to lead into the passage first, and branches are to go to the office rooms and the wash room.

The returns or drips from coils must lead to a steam trap of approved pattern and ample capacity, which must be arranged to allow air and water of condensation to escape from pipes without loss of steam. The trap is to discharge, if possible, into the 3-inch drain or waste pipe from the sinks. All long lines of pipes must be provided with miters arranged to allow for expansion. All parts of the heating plant must be properly dripped.

All pipes must be standard wrought-iron steam pipe; all sizes above 1¼ inches to be lap welded; all fittings to be of cast iron; all valves must be Fairbanks, Jenkins, or Scott disk valves. All materials to be used must be of the best quality.

All cutting in walls and floors for the passage of pipes will be done by the contractor.

The plant is to be furnished complete with steam on.

Bids will be received for the following items:

1. For all work specified under headings: Excavations and grading, concrete and masonry work.
2. Price per 1,000 for furnishing the brick that may not be on hand at arsenal, delivered at building site.
3. For all work specified under heading: Carpenter work (including windows and doors) and painting.
4. For all work specified under headings: Water closet, sinks in wash room, and steam heating arrangement, which includes all plumbing and pipe-fitting.
5. For all work specified under heading: Slating and tinning.

Combined bids will be received also for several or all of the above items.

Bidders will please state the approximate time within which they propose to finish the work.

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Should the contractor feel aggrieved at any decision of the commanding officer under these specifications, he shall have the right to appeal to the Chief of Ordnance, U. S. A., and his decision shall be final.

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*Statement of stores fabricated at Watervliet Arsenal during the fiscal year ended June 30, 1891.*

### Class 1.

25 3.2-inch breech-loading rifles, steel.
1 12-inch breech-loading rifle, steel, type No. 1.
4 12-inch breech-loading mortar, steel, type No. 1.

### Class 2.

1 carriage for 3.6-inch B. L. field mortar.
22 caissons and limbers for 3.2-inch guns.
6 combined forges and battery wagons.
20 limbers for machine-gun carriages.
2 mortar wagons.

### CLASS 3.

25 buckets, water, galvanized iron.
18 fuse wrenches for 3.2-inch shell.
2 gunners' gimlets for 10-inch Rodman gun.
2 gunners' gimlets for 15-inch Rodman gun.
2 gunners' gimlets for 13-inch mortar.
13 gunners' reamers, 3.2-inch rifle.
2 Gatling-gun covers, model 1883, caliber .45.
32 handspikes, maneuvering, for 3.2-inch rifle.
6 handspikes, maneuvering, 8-inch.
15 harness, artillery, for 2 wheel horses, new pattern, sets.
15 harness, artillery, for 2 lead horses, new pattern, sets.
1 harness bag for new model harness.
2 lanyards, new pattern.
1 maul.
3 mauls for mortar.
1 priming wire for 3.2-inch B. L. rifle.
9 priming wires for 10-inch Rodman gun.
2 priming wires for 13-inch mortars.
2 primer pouches 3.2-inch rifle.
1 pendulum hausse pouch, 3-inch rifle.
12 prolonges (section of picket rope).
3 pouches, sight, for 4½-inch rifle.
1 quoin for 8-inch siege-howitzer carriage.
8 rammers and staves for 4½-inch siege gun.
2 rammers and staves for 11-inch rifle.
10 short rammers and sponges combined, 3.2-inch rifle.
15 sponges and rammers, jointed, 3.2-inch rifle.
8 sponges and staves for 8-inch converted rifle, spring head.
8 sponges and staves for 10-inch gun, spring head.
9 sponges and staves for 13-inch mortar, spring head.
5 sponge covers, bore, 3.2-inch rifle.
18 sponge covers, chamber, 3.2-inch rifle.
11 scrapers for cannon, outside.
4 scrapers for carriages.
42 thumbstalls.
1 vent punch, 3.2-inch rifle.
6 vent punches, 15-inch gun.
2 vent pieces, 3-inch rifle.
1 vent piece, 3.2-inch rifle.
2 vent pieces, 6-pounder gun.
1 vent piece, light 12-pounder gun.
7 vent covers.
48 vent covers for 8-inch converted rifle.
20 vent covers for 4½-inch and 8-inch guns.
20 vent covers for 15-inch smoothbore guns.

### CLASS 4.

6,173 cast-iron shells, long, for 3.2-inch B. L. field guns.
720 cast-iron shells, long, for 3.6-inch B. L. field guns.
1,050 cast-iron shells, for 5-inch siege guns.
637 cast-iron shells, for 7-inch siege howitzer.
1,000 Eureka cast-iron shells, for 8-inch converted rifles.
186 10-inch solid shot, each 575 pounds.
50 12-inch solid shot, each 1,000 pounds.

### CLASS 7.

291 bayonet scabbards, steel, with Hoffman's attachment.
1,290 cartridge boxes, McKeever.
96 saddle cloths, cotton, scarlet.
3 waist belts.
2 waist-belt plates (without loops).

### CLASS 9.

16 blocks, 4 feet by 12 inches by 1 inch.
10 blocks, 4 feet by 12 inches by 2 inches.
5 blocks, 4 feet by 12 inches by 4 inches.

3 blocks, 20 inches by 8 inches by 2 inches.
1 block, double, for 15-inch shears.
1 block, single, for 15-inch shears.
1 block, snatchwood, for 5½-inch rope.
40 chocks, roller.
40 chocks, wheel.
20 chocks, gun.
20 chocks, 15-inch gun.
1 cap shears.
1 cradle for 8-inch and 10-inch guns.
6 floor boards for 8-inch Rodman gun carriage sets.
1 gin, garrison.
3 handspikes, gin.
1 platform for 4½-inch rifle.
10 platforms for siege guns.
4 platforms for 8-inch and 10-inch siege mortars.
10 platforms for siege mortars.
6 rollers, short.
6 rollers, 2-inch.
18 rollers, 5-inch.
18 rollers, 6-inch.
18 rollers, 7-inch.
6 rollers, oak, 8 inches diameter, 4 feet long.
6 rollers, oak, 8 inches diameter, 3 feet long.
18 rollers, cradle.
2 skids, oak, 96 inches by 12 inches by 12 inches.
12 traveling planks, 16 feet by 10 inches by 2 inches.
48 way planks.

## CLASS 10.

### PARTS APPERTAINING TO CLASS 1.

1 De Bange obturator.
1 De Bange obturator pad.
6 Freyre obturators.
2 Freyre obturator gas-check rings.
} For 3.2-inch B. L. rifle.
2 gas-check pads, for 7-inch B. L. howitzer.
30 gas-check pads, for 12-inch cast-iron mortar, hooped.
1 gas-check pad, for 10-inch W. W. rifle, C. I.

### PARTS APPERTAINING TO CLASS 2.

2 ammunition chests for limbers, 3.2-inch rifle.
4 braces, metallic, for lid of ammunition chest.
3 bronze screw lids for primer box.
5 canvas covers for ammunition chests, 3.2-inch rifle.
12 corrugated plates, 3.2-inch limbers.
4 cap squares.
2 double trees, special pattern.
} For 3.2-inch limbers.
1 double and 2 single trees, steel.
8 doubletrees.
17 singletrees.
40 linchpins.
46 linch washers.
13 neck-yokes.
3 poles, spare.
2 poles, not ironed.
4 pole-props for end of pole.
2 pole-prop springs and hooks.
} For 3.2-inch limbers.
5 road-brakes for caisson 3.2-inch gun, pairs.
1 road-brake for battery-wagon, pair.
1 stay-pin and chain for ammunition chest.
5 spring clasps for handspikes, maneuvering, 3.2-inch.

### PARTS APPERTAINING TO CLASS 3.

2 breast straps for double harness, pairs.
140 breast-strap hooks.
132 back-strap hooks and D-rings.

7 collars, artillery.
132 collar straps.
132 collar-strap hooks and D-rings.
428 rings, 4-inch.
400 saddle thongs.
132 trace chains, wheel.
132 trace chains, lead.
2 traces, lead.
2 traces, wheel.
1 martingale.
5 pole-pads, rubber.
30 sponge heads, bore, 3.2-inch gun.
24 sponge heads, chamber, 3.2-inch gun.
12 sponges, woolen, 4½-inch rifle.
4 sponges, woolen, 8-inch converted rifle (spring head).
4 sponges, woolen, 8-inch converted rifle (12 pieces).
10 sponges, woolen, 10-inch smooth-bore gun (solid head).
41 sponges, woolen (spring head), 15-inch gun (123 pieces).

### PARTS APPERTAINING TO CLASSES 4 AND 5.

1,000 base plugs, wrought-iron, for 3.2-inch shells.
500 base plugs, wrought-iron, for 3.6-inch shells.
200 base plugs, wrought-iron, for 7-inch shells.
400 copper bands for 3.2-inch shells.
200 sabots. }
200 tin straps. } For 15-inch projectiles.
25 copper bands for 12-inch mortar shell.

### PARTS APPERTAINING TO CLASS 8.

25 cartridge bags for 4½-inch rifle, 3½-pound charge.
100 cartridge bags for 10-inch Rodman gun.

### PARTS APPERTAINING TO CLASS 9.

4 poles for hand sling cart.
1 pole for large sling cart.
1 wheel, hand sling cart, iron.

## *PART SECOND.*

### PAINTS, OILS, DYES, ETC.

341 pounds paint for 3.2-inch B. L. rifles.

### MISCELLANEOUS ARTICLES.

1,971 boxes, packing.
1 wooden model, 10-inch B. L. rifle.

### INSPECTING INSTRUMENTS, RINGS, GAUGES, ETC.

1 cylinder gauge for testing straightness of bore for 8-inch rifle.
1 gauge for testing gas-check seat. }
6 profile templets for verifying threads of breech blocks and breech bushings of 8-inch guns. } For 8-inch rifle.

### TOOLS, UTENSILS, AND OTHER MISCELLANEOUS ARTICLES.

18 aprons, smiths', leather.
6 coal bags. }
36 tool bags (small canvas bags). } For 3.2-inch B. L. rifle caissons and limbers.
25 tool boxes. }
1 iron nut wrench, 12 inches long.
1 ¾-inch cold chisel by 8 inches long.
1 small steel punch.

6 grindstones, arbor cranks and frames.
6 mallets, wood.
1 muzzle and stencil ring for marking 12-inch cast-iron steel-hooped mortars.
6 oil cans, coal (3 gallons).
6 oil cans, sperm (2½ pints).
Oilers for gattling gun, model 1883.
6 stitching horses.
61 wheel-grease cans.
25 wheel-grease can knives.

### *UNFINISHED WORK IN HAND.*

#### CLASS 1.

25 3.2-inch B. L. rifles, steel.
1 3.2-inch B. L. rifle, steel, with Driggs-Schroeder breech mechanism.
1 3.2-inch B. L. rifle, steel, with Gerdom breech mechanism.
10 5-inch B. L. rifles, steel, siege.
10 7-inch B. L. howitzers, steel.
12 8-inch B. L. rifles, steel, Nos. 2 to 13, inclusive.
1 10-inch B. L. rifle, steel, wire-wound, Crozier design.
23 10-inch B. L. rifles, steel, Nos. 2 to 24, inclusive.

#### CLASS 2.

25 caissons and limbers for 3.2-inch B. L. rifles.
6 combined forges and battery wagons.
25 limbers for 3.2-inch B. L. rifles.

#### CLASS 4.

1,792 cast-iron shells, long, for 3.2-inch B. L. field gun.
980 cast-iron shells, long, for 3.6-inch B. L. field gun.
413 cast-iron shells, for 7-inch B. L. siege howitzer.
180 10-inch shot, Woodbridge gun, 575 pounds.
84 10-inch solid shot, Crozier gun, 575 pounds.
200 12-inch solid shot, each 1,000 pounds.

#### CLASS 10.

#### PARTS CLASS 2.

17 hasps. } For ammunition chest, 3.2-inch limber.
4 turn-buckles. }

### *PART SECOND.*

#### INSPECTING INSTRUMENTS—RINGS, GAUGES, ETC.

1 plug for testing thread in base bushing ring for 8-inch gun work.
1 ring for testing thread of breech block for 8-inch gun work.

PLATE I.

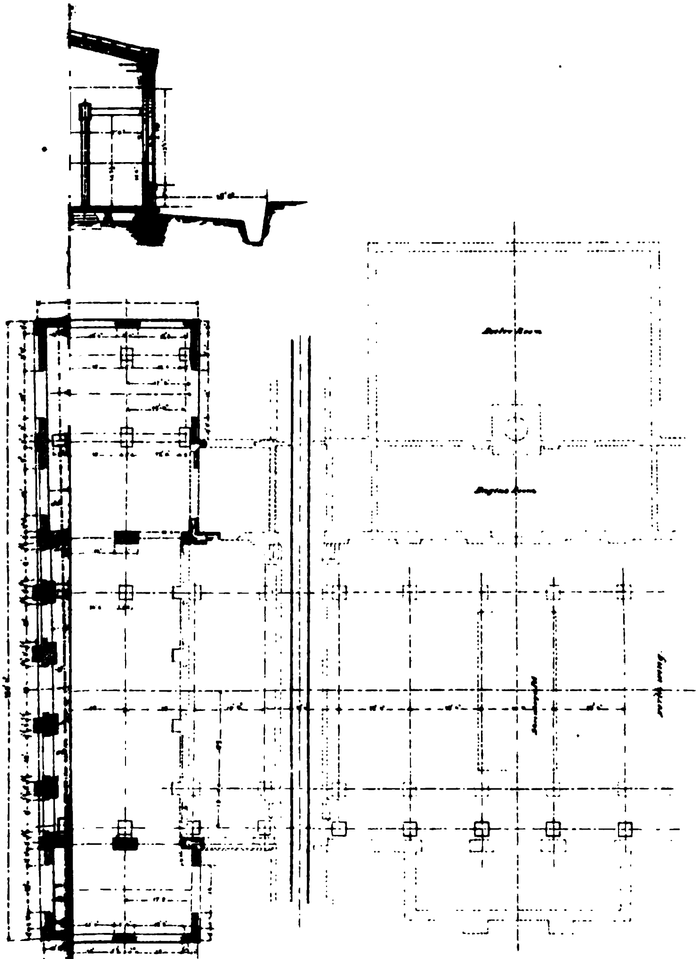

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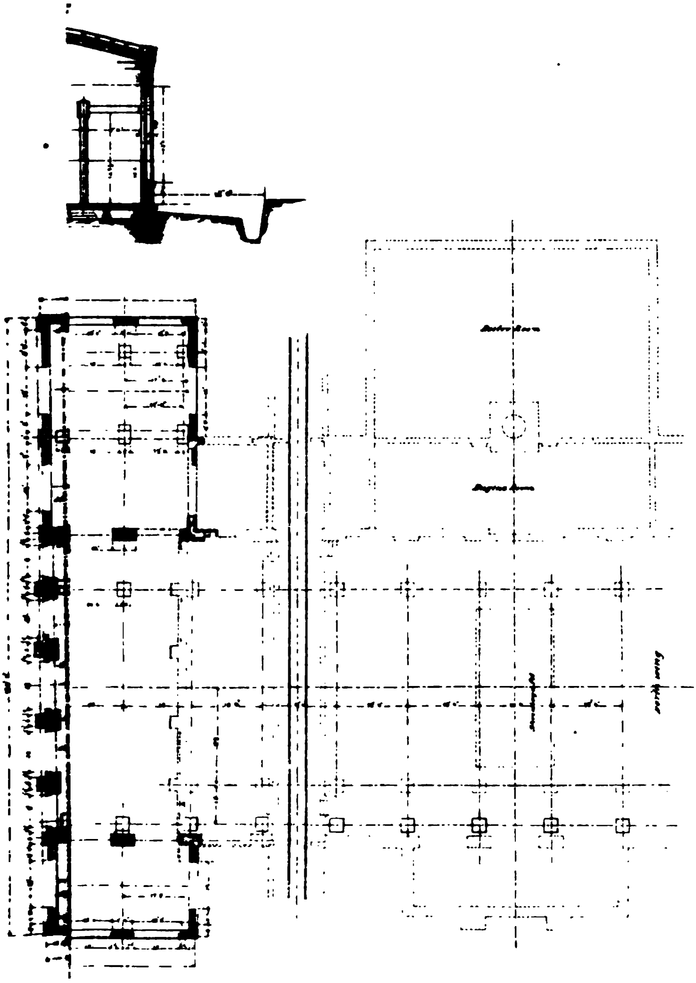
PLATE I.



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# APPENDIX 13.

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## REPORTS ON SMOKELESS POWDER.

### No. 1.

SPRINGFIELD ARMORY,
*Springfield, Mass., November 1, 1890.*

(1) *Maxim smokeless powder.*—This powder is similar in appearance to the Maxim powder lately tested at this armory and reported upon under date of October 2, 1890. That powder, however, was stated by Mr. Maxim to be composed of 50 per cent gun cotton, 48 per cent nitroglycerin, and 2 per cent castor oil, while the powder, the subject of this report, is understood to contain 74 per cent gun cotton, 25 per cent nitroglycerin, and 1 per cent castor oil—a substitute of gun cotton for about one-half of the nitroglycerin.

The limited amount of powder would not admit of extended trials similar to those made in England, but the test was conducted for velocity and pressure to the full extent possible, with results as given below.

*Maxim smokeless powder.*

[74 per cent gun cotton, 25 per cent nitroglycerin, 1 per cent castor oil.]

| Charge. | Shot. | Pressure. | Velocity. | Charge. | Shot. | Pressure. | Velocity. |
|---|---|---|---|---|---|---|---|
| 30 grains...... | 1 | 25,000 | 1,560 | 36 grains...... | 5 | 44,000 | 1,910 |
| | 2 | 25,000 | 1,558 | | | | |
| 32 grains...... | 1 | 32,000 | 1,712 | Mean............ | | 49,200 | 1,961.2 |
| | 2 | 31,000 | 1,696 | | | | |
| | | | | 37 grains...... | 1 | 49,500 | 1,980 |
| 34 grains...... | 1 | 40,500 | 1,847 | | 2 | 56,200 | 2,056 |
| | 2 | 34,500 | 1,815 | | 3 | 52,600 | 1,978 |
| | 3 | 32,500 | 1,789 | | 4 | 47,100 | 1,956 |
| | 4 | 38,300 | 1,833 | | 5 | 50,200 | 1,986 |
| | 5 | 40,200 | 1,854 | | 6 | 50,200 | 1,986 |
| | | | | | 7 | 53,200 | 1,992 |
| Mean............. | | 37,200 | 1,827.8 | | 8 | 50,200 | 1,992 |
| | | | | | 9 | 53,200 | 2,010 |
| 36 grains...... | 1 | 51,300 | 1,994 | | 10 | 53,000 | 1,990 |
| | 2 | 50,800 | 1,970 | | | | |
| | 3 | 50,700 | 1,960 | Mean.............. | | 51,770 | 1,992.6 |
| | 4 | 49,200 | 1,972 | Extreme variation. | | 9,100 | 100 |

Comparing these results with those of the English trials no very wide divergence is noticeable. The English bullet weighs 216 grains, while that used here weighs 230 grains; hence slightly greater charges would probably be required to produce equal velocities, but necessarily at the cost of increased pressure.

The results anticipated were realized.

In England 34 grains gave a mean *muzzle* velocity of 2,012 feet; here 37 grains gave an *instrumental* velocity of 1,992 feet, which would be a muzzle velocity somewhat superior to the English.

In England 34 grains gave a pressure with the 216-grain bullet of about 34,000 pounds; here 34 grains with the 230-grain bullet gave with the gauge in use at this armory a pressure of 37,000, while 37 grains produced a pressure of about 52,000 pounds.

With 37 grains the Springfield experimental caliber .30 shell was just filled, the charge being well shaken down by tapping, but not at all compressed.

This Maxim compared with that of similar form (report from this armory of October 2) would appear to give somewhat increased velocities for equal pressures, to produce which one or two more grains are required.

The powder is, however, open to the same objections as expressed in the report above mentioned.

(2) *Smokeless powder (no name) from St. Petersburg.*—As the sample comprised a quantity so small no test could be made and the powder is returned herewith.

The reported velocity (2,020 feet) has frequently been obtained here in testing other powders, but never with such a moderate pressure (about 35,000 pounds) as that stated by Lieut. Allen.

(3) *Kubin-Schwabe smokeless powder from Vienna.*—All the powder in the sample, weighing only 18 grains, was loaded with one of our 230-grain bullets and fired, giving a velocity of 950 feet, with pressure under 10,000 pounds. Evidently the proper charge is considerably in excess of 18 grains.

The powder presented the appearance of having been made in strings or cords somewhat like vermicelli, and of about 0.025 inch in diameter, and then cut into lengths which varied between 0.02 and 0.06 inch. Apparently the powder had been treated to a light coating of graphite, giving it a slight gloss and dark color, under which, viewed through a magnifying glass, could be discerned the drab or brownish color characteristic of so many of the smokeless powders, notably the Maxim.

Respectfully,

S. E. BLUNT,
*Captain, Ordnance Department.*

(Inc. 1, 6467-'90.)

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## No. 2.

### REPORT OF TRIAL OF FRENCH B. N. POWDER.

SPRINGFIELD ARMORY,
*Springfield, Mass., February 4, 1891.*

Col. A. R. BUFFINGTON,
*Commanding:*

SIR: I have the honor, in accordance with your verbal directions, to make the following report of the trials of a sample of French B. N. powder lately received from the Ordnance Office.

The letter forwarding this powder states that it is understood to be similar to the standard B. N. French powder (of the trial of which at this armory a report was submitted under date of July 18, 1890), except that it has been adulterated to yield smoke.

In appearance it is similar to that standard French powder, being in the same thin striated sheets, and drab or gray in color.

These sheets are about 0.03 inch thick, 3.12 inches long and 1.1 inches wide. Broken into strips along the grooves the resulting pieces are 3.12 inches long and 0.066 inch wide.

Trials were commenced with a charge composed of these strips cut into halves, that length corresponding to the powder space in the shell. But 35 grains could be introduced, and that charge gave a pressure of 12,000 pounds and a velocity of 1,176 feet.

Cutting the strips into eighths a thin, narrow grain nearly 0.4 inch long was produced, which in a charge of 35 grains (nearly filling the shell) produced a velocity of 1,217 feet, with a pressure of 14,000 pounds. In both these cases, however, the charge hung fire, discharge following at an appreciable interval after the explosion of the primer.

It was then decided to reduce the size of the grains as in the former trials of this powder. The narrow strips were accordingly cut into lengths about equal to their width, producing a thin, flat, nearly square grain, and with these the following tests were conducted:

| Charge. | Shot. | Pressure. | Velocity. | Charge. | Shot. | Pressure. | Velocity. |
|---|---|---|---|---|---|---|---|
| | | *Pounds.* | *Feet.* | | | *Pounds.* | *Feet.* |
| 35 grains...... | 1 | 24,000 | 1,428 | 42 grains...... | 1 | 45,600 | 1,811 |
| | 2 | 24,000 | 1,405 | | 2 | 43,800 | 1,813 |
| 38 grains...... | 1 | 30,400 | 1,583 | | 3 | 46,800 | 1,843 |
| | 2 | 31,000 | 1,583 | | 4 | 48,500 | 1,860 |
| | | | | | 5 | 45,600 | 1,838 |
| 40 grains...... | 1 | 34,500 | 1,688 | | 6 | 46,500 | 1,823 |
| | 2 | 32,600 | 1,654 | | 7 | 50,000 | 1,862 |
| | 3 | 34,000 | 1,645 | | 8 | 43,800 | 1,815 |
| | 4 | 41,200 | 1,718 | | 9 | 47,000 | 1,858 |
| | 5 | 32,000 | 1,672 | | 10 | 36,600 | 1,767 |
| | 6 | 36,300 | 1,683 | | 11 | 53,900 | 1,765 |
| | 7 | 36,600 | 1,730 | | 12 | 39,600 | 1,749 |
| | 8 | 32,600 | 1,669 | | 13 | 40,200 | 1,770 |
| | 9 | 32,800 | 1,674 | | 14 | 43,800 | 1,802 |
| | 10 | 33,700 | 1,670 | | 15 | 39,400 | 1,769 |
| Mean ............ | | 34,630 | 1,680.3 | Mean ............ | | 44,740 | 1,803 |
| Extreme variation. | | 8,600 | 76 | Extreme variation. | | 17,300 | 113 |
| 41 grains...... | 1 | 38,400 | 1,769 | 43 grains...... | 1 | 41,600 | 1,812 |
| | 2 | 42,300 | 1,775 | | 2 | 50,100 | 1,840 |
| | 3 | 44.400 | 1,763 | | 3 | 41,700 | 1,826 |
| | 4 | 41,100 | 1,789 | | 4 | 59,500 | 1,910 |
| | 5 | 42,300 | 1,767 | | 5 | 52,800 | 1,948 |
| | 6 | 39,400 | 1,743 | | 6 | 53,400 | 1,918 |
| | 7 | 41,700 | 1,792 | | 7 | 68,000 | 1,972 |
| | 8 | 41,200 | 1,792 | | 8 | 59,100 | 1,948 |
| | 9 | 45,600 | 1,804 | | 9 | 45,600 | 1,885 |
| | 10 | 36,600 | 1,767 | | 10 | 44,000 | 1,854 |
| Mean ............ | | 41,300 | 1,776.1 | Mean ............ | | 51,620 | 1,891.3 |
| Extreme variation. | | 7,200 | 61 | Extreme variation. | | 26,400 | 160 |

All velocities are instrumental, and at 50 feet from the muzzle—bullet lead with copper jacket, weight 230 grains, caliber .30. With 41 grains of the powder the shell was filled to base of bullet when powder was shaken down by gently tapping on the shell as it was loaded; with 40 grains it was nearly filled to same point with no more tapping than necessary, on account of tendency of grains to clog and wedge, to facilitate loading. With 42 grains, and to a still greater extent with 43 grains, the powder was packed together as the bullet was forced home to its regular position, with the higher charge the column of powder being compressed about half an inch. The effect of this compression is very noticeable, both pressures and velocities being far from uniform, the former varying between 41,600 and 68,000 pounds, and the velocities between 1,812 and 1,972 feet in only ten shots when the charge was 43 grains, and to a marked extent also for 42 grains. In both of these cases, also, great pressures do not correspond to high velocities, nor are the higher velocities always accompanied by the extreme pressures. It is evident that the charge will not bear compression.

With 40 and 41 grains both pressures and velocities are fairly uniform; the former quite moderate, but so also, when compared with some other powders which have been tried at this armory, are the velocities.

The smoke from the discharge was much lighter and thinner than from gunpowder, was moderate in quantity and slowly dissipated. Several of the strips laid together and ignited in the open air burned slowly with an intense white flame tipped with red. A sheet of the powder burned in a similar manner. In a train of the square grains to which the powder was reduced for charging the cartridges, it burnt with its characteristic flame and very much slower than a similar train of gunpowder. In all cases a slight granular ash was left and a smoke produced which, however, soon disappeared. The fouling of the barrel was slight and rather dry and hard.

A comparison of the powder with the "B. N." (smokeless) tested last July is exhibited in the following table:

*French "B. N." smokeless and smoke producing, compared.*

| Charge. | Smokeless. | | Smoke producing. | |
|---|---|---|---|---|
| | Pressure. | Velocity. | Pressure. | Velocity. |
| | *Pounds.* | *Feet.* | *Pounds.* | *Feet.* |
| 40 grains | 46,360 | 1,763 | 34,630 | 1,680 |
| 41 grains | 53,470 | 1,857 | 41,300 | 1,776 |
| 42 grains | 57,907 | 1,905 | 44,740 | 1,803 |

Examining this table it appears that the addition of the smoke producing adulterant has resulted in a powder which for an equal charge gives about 12,000 pounds less pressure and 80 to 100 feet less velocity than the smokeless variety; but when charges (without regard to their weight) giving nearly similar pressures are compared there appears to be a material gain in the velocity. The powder capacity of the experimental cartridge not permitting the advantageous use of more than 41 grains of the powder, it was not possible to increase the charge so as to produce the greater pressures found with the smokeless variety, or to obtain the increase in velocity that would probably result in the larger powder space which this powder evidently requires.

Very respectfully, your obedient servant,

S. E. BLUNT,
*Captain, Ord. Dept., U. S. Army.*

(927-'91.)

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## No. 3.

SPRINGFIELD ARMORY,
*Springfield, Mass., March 23, 1891.*

Col. A. R. BUFFINGTON,
*Commanding:*

COLONEL: In accordance with your verbal directions I have the honor to make the following report of the trials of a smokeless powder brought to this armory by W. B. Houghton, of North Adams, Mass., and understood to be the joint invention of Mr. Houghton and Dr. Robert Schapphaus:

Mr. Houghton first visited the armory in November last with a powder which he desired tested, and on five different occasions since has either brought or sent additional samples, which were tried and the results communicated to him.

In its earlier forms the powder was entirely unsuited to the military service, giving abnormally high pressures with very moderate velocities and being of uncertain ignition. The requirements of a powder for small arms, the necessity for uniformity in the composition, and regularity in the size and shape of the grains were all explained to Mr. Houghton, who, taking advantage of the suggestions thus conveyed, has progressively improved his powder and finally succeeded in producing one which, with moderate pressures, gives high velocities and uniform results.

Mr. Houghton has not stated definitely the composition of the powder, but judging from its appearance and action it must be somewhat similar to the Maxim, which, according to report, is a compound of gun cotton and nitroglycerin. The grains are approximately cubes of about 0.05 inch on an edge, are soft and easily cut with a knife, and dark brown in color. In the open air the powder ignites and burns slowly with a white blaze and no appreciable smoke or ash; in the gun it gives a strong, sharp report, no smoke and no odor, and barely a trace of fouling.

The quality of this last sample of the powder being known from the previous trials, many preliminary shots were not necessary; but one, a charge of 27 grains, which gave 1,727 feet initial velocity with a pressure of 34,000 pounds, was fired before proceeding with the trials, as follows:

| Charge. | Shot. | Pressure. | Velocity. |
|---|---|---|---|
| | | *Pounds.* | *Feet.* |
| 30 grains...... | 1 | 46,500 | 1,862 |
| | 2 | 44,400 | 1,847 |
| | 3 | 40,500 | 1,862 |
| | 4 | 43,800 | 1,870 |
| | 5 | 43,800 | 1,854 |
| | 6 | 43,800 | 1,873 |
| | 7 | 44,400 | 1,900 |
| | 8 | 32,000 | 1,815 |
| | 9 | 32,900 | 1,850 |
| | 10 | 44,500 | 1,894 |
| Mean............... | | 41,650 | 1,862.7 |
| Extreme variation. | | 14,500 | 85 |
| 32 grains...... | 1 | 50,000 | 1,970 |
| | 2 | 49,200 | 1,954 |
| | 3 | 47,100 | 1,944 |
| | 4 | 52,200 | 1,966 |
| | 5 | 52,200 | 1,970 |
| | 6 | 52,200 | 1,976 |
| | 7 | 54,600 | 1,990 |
| | 8 | 53,500 | 1,988 |
| | 9 | 53,500 | 1,992 |
| | 10 | 53,400 | 2,000 |
| | 11 | 53,400 | 1,980 |
| | 12 | 50,000 | 1,952 |
| | 13 | 45,000 | 1,929 |
| | 14 | 47,100 | 1,974 |
| | 15 | 49,800 | 1,952 |
| | 16 | 49,800 | 1,952 |
| | 17 | 51,300 | 1,968 |
| 32 grains...... | 18 | 47,400 | 1,942 |
| | 19 | 50,000 | 1,978 |
| | 20 | 50,000 | 1,956 |
| Mean............... | | 50,585 | 1,966.5 |
| Extreme variation. | | 9,600 | 71 |
| 33 grains...... | 1 | 58,200 | 2,034 |
| | 2 | 57,600 | 2,032 |
| | 3 | 56,600 | 2,034 |
| | 4 | 54,100 | 2,014 |
| | 5 | 58,800 | 2,054 |
| | 6 | Lost...... | 2,054 |
| | 7 | 55,800 | 2,034 |
| | 8 | 60,600 | 2,046 |
| | 9 | 60,600 | 2,056 |
| | 10 | 59,200 | 2,072 |
| Mean............... | | 57,878 | 2,043 |
| Extreme variation. | | 6,500 | 58 |
| 34 grains...... | 1 | 59,000 | 2,070 |
| | 2 | 54,800 | 2,042 |
| | 3 | 50,200 | 1,986 |
| | 4 | 58,200 | 2,072 |
| | 5 | 62,700 | 2,104 |
| | 6 | 54,000 | 2,058 |
| | 7 | 57,300 | 2,052 |
| | 8 | 54,000 | 2,012 |
| Mean............... | | 56,275 | 2,049.5 |
| Extreme variation. | | 12,500 | 118 |

In these trials the experimental pressure barrel, caliber .30, was employed; the bullet (lead with copper jacket) weighed 230 grains, and the recorded velocities are instrumental at a distance of 50 feet from the muzzle.

Owing to the shape and smoothness of the grain the powder was readily loaded, and from its high specific gravity the charges used occupied but a portion of the shell, leaving a space between the powder and bullet. As the shell will hold 41¼ grains of the powder the considerable amount of this space is evident.

As compared with other powders tested at the armory during the last eighteen months, this powder of Mr. Houghton's, when the ease with which it can be loaded, the regularity of the results, the moderate pressures with high corresponding velocities are all considered, appears to be inferior to none and superior to the great majority.

The influence of moisture or heat and the effect of storage upon the stability of the powder have not yet been tried. An additional amount is expected from Mr. Houghton, which will permit these features to be tested. If the results are satisfactory the powder may be considered as one well adapted for use in military small arms.

Very respectfully, your obedient servant,

S. E. Blunt,
*Captain, Ord. Dept., U. S. Army.*

(1841-'91.)

## No. 4.

## REPORT UPON THE TRIAL OF A FORM OF WETTEREN SMOKELESS POWDER.

Springfield Armory,
*Springfield, Mass., April 11, 1891.*

Col. A. R. Buffington,
*Commanding:*

Colonel: I have the honor to make the following report of the test made to-day, in accordance with your verbal directions, of the Wetteren smokeless powder intended for the cartridges to be used by the Magazine Gun Board in the test of arms submitted for their examination:

This powder possesses all the characteristic features of the Wetteren powder, which were mentioned at length in the reports forming Appendix 15 of the report of the Chief of Ordnance for 1890 and Report No. 6 of Appendix 14. The form and appearance of the grain more nearly resembles the latter powder (those termed Du Pont), while in its ballistic properties it seems to lie midway between the two powders as regards the weight of charge required to produce an equal pressure, but is superior to both in that the accompanying velocity is now greater.

The preliminary shots were fired with 29, 30, 34, and 36 grains, two shots each, with following results: 29 grains, pressures 29,000 and 24,500; 30 grains, pressures 28,600 and 26,800; 34 grains, pressures 36,000 and 38,400; 36 grains, pressures 49,000 and 46,000.

Trials were then continued, determining velocities as well as pressures, as follows:

*Wetteren smokeless powder.*

| Charge. | Shot. | Pressure per square inch. | Velocity per second. | Charge. | Shot. | Pressure per square inch. | Velocity per second. |
|---|---|---|---|---|---|---|---|
| | | *Pounds.* | *Feet.* | | | *Pounds.* | *Feet.* |
| 36 grains...... | 1 | 46,000 | 1,865 | 37 grains...... | ...... | 56,000 | 1,942 |
| | 2 | 50,400 | 1,860 | | | 54,600 | 1,944 |
| | 3 | 50,800 | 1,896 | | | 55,200 | 1,932 |
| | 4 | 44,600 | 1,859 | | | 52,800 | 1,938 |
| | 5 | 47,000 | 1,853 | | | 58,800 | 1,946 |
| | 6 | 49,200 | 1,888 | | | 61,800 | 1,984 |
| | 7 | 46,000 | 1,898 | | | 62,700 | 1,998 |
| | 8 | 44,800 | 1,859 | | | 56,800 | 1,992 |
| | 9 | 49,600 | 1,876 | | | 46,700 | 1,929 |
| | 10 | 46,000 | 1,855 | | | 54,000 | 1,948 |
| | 11 | 48,600 | 1,879 | | | 49,600 | 1,925 |
| | 12 | 51,000 | 1,904 | | | 50,000 | 1,930 |
| | 13 | 51,500 | 1,898 | | | 52,000 | 1,976 |
| | 14 | 46,500 | 1,875 | | | 54,600 | 1,962 |
| | 15 | 44,800 | 1,866 | | | 51,000 | 1,924 |
| | 16 | 49,500 | 1,908 | | | 54,600 | 1,956 |
| | 17 | 45,000 | 1,866 | | | 50,000 | 1,916 |
| | 18 | 46,500 | 1,873 | | | 60,600 | 1,960 |
| | 19 | 48,600 | 1,873 | | | 61,000 | 1,992 |
| | 20 | 48,000 | 1,869 | | | 54,600 | 1,956 |
| Mean ............ | | 47,720 | 1,876 | Mean ............ | | 54,870 | 1,952.5 |
| Extreme variation. | | 6,900 | 55 | Extreme variation. | | 13,100 | 82 |

All velocities instrumental and at 50 feet from the muzzle; charges fired from the 0.30 caliber pressure barrel; bullet lead, with copper jacket, weight 230 grains.

With 36 grains the shell is full to base of bullet; powder shaken down but not compressed. With 37 grains the powder is slightly packed together by the pressure necessary to seat the bullet in its proper position. This compression appears to influence in a marked degree the uniformity of the result, which for twenty shots vary between 62,700 and 49,600 pounds pressure and 1,998 and 1,916 feet velocity, while in the smaller uncompressed charge the pressures lie between 51,500 and 44,600 pounds, and the velocities between 1,908 and 1,853, variations only slightly more than one-half of these accompanying the 37-grain charge.

While 55,000 pounds may not be an excessive pressure for the tests of the Magazine Gun Board, the probability of every few shots exceeding this pressure by at least 7,000 pounds would make the 37-grain charge undesirable, especially when it is remembered that the variations attending loading the cartridges by machinery would often give a charge exceeding the standard by one-half a grain or even more, with the much increased attendant pressure.

It is therefore recommended that 36 grains of this powder be established as the standard charge for the experimental cartridges.

Very respectfully, your obedient servant,

S. E. Blunt,
*Captain, Ord. Dept., U. S. Army.*

(2373-'91.)

## No. 5.

## SECOND REPORT ON WETTEREN SMOKELESS POWDER.

SPRINGFIELD ARMORY,
*Springfield, Mass., May 8, 1891.*

Col. A. R. BUFFINGTON,
*Commanding:*

SIR: I have the honor to submit additional report of further trials, lately made in accordance with your verbal directions, of the Wetteren smokeless powder intended for the cartridges to be used by the Board on Magazine Arms in the trials of guns submitted.

Shots were fired with charges of 33, 34, 35, and 36 grains, both in the caliber .30 barrel, by which pressures and velocities are determined simultaneously, and in the caliber .30 experimental Springfield rifle, with results as given below:

| Charge. | Caliber .30 pressure barrel. | | | Springfield caliber .30 gun. | |
|---|---|---|---|---|---|
| | Shot. | Pressure. | Velocity, instrumental. | Shot. | Velocity, instrumental. |
| 33 grains ......... | 1 | 46,600 | 1,823 | 1 | 1,881 |
| | 2 | 47,410 | 1,811 | 2 | 1,879 |
| | 3 | 47,400 | 1,803 | 3 | 1,878 |
| | 4 | 49,800 | 1,862 | 4 | 1,857 |
| | 5 | 51,200 | 1,878 | 5 | 1,900 |
| | 6 | 47,600 | 1,871 | 6 | 1,924 |
| | 7 | 47,800 | 1,866 | 7 | 1,910 |
| | 8 | 50,000 | 1,849 | 8 | 1,898 |
| | 9 | 53,600 | 1,873 | 9 | 1,890 |
| | 10 | 50,200 | 1,842 | 10 | 1,926 |
| | 11 | 48,400 | 1,831 | 11 | 1,914 |
| | 12 | 48,400 | 1,838 | 12 | 1,908 |
| | 13 | 53,200 | 1,862 | 13 | 1,898 |
| | 14 | 54,800 | 1,881 | 14 | 1,896 |
| | 15 | 49,400 | 1,885 | 15 | 1,906 |
| | 16 | 49,600 | 1,830 | 16 | 1,932 |
| | 17 | 52,200 | 1,879 | 17 | 1,928 |
| | 18 | 51,600 | 1,881 | 18 | 1,906 |
| | 19 | 50,400 | 1,866 | 19 | 1,912 |
| | 20 | 50,600 | 1,870 | 20 | 1,914 |
| Mean ................ | | 50,010 | 1,855.1 | ....... | 1,902.9 |
| Corresponding muzzle velocity.... | | | 1,887.9 | ....... | 1,936.6 |
| 34 grains ......... | 1 | 57,000 | 1,938 | 1 | 1,936 |
| | 2 | 52,800 | 1,883 | 2 | 1,940 |
| | 3 | 46,600 | 1,866 | 3 | 1,924 |
| | 4 | 57,200 | 1,968 | 4 | 1,929 |
| | 5 | 51,200 | 1,887 | 5 | 1,950 |
| | 6 | 60,200 | 1,948 | 6 | 1,944 |
| | 7 | 55,600 | 1,890 | 7 | 1,952 |
| | 8 | 53,600 | 1,878 | 8 | 1,956 |
| | 9 | 53,200 | 1,918 | 9 | 1,940 |
| | 10 | 49,800 | 1,894 | 10 | 1,980 |
| | 11 | 50,000 | 1,875 | 11 | 1,908 |
| | 12 | 50,000 | 1,873 | 12 | 1,914 |
| | 13 | 51,200 | 1,879 | 13 | 1,948 |
| | 14 | 50,200 | 1,870 | 14 | 1,930 |
| | 15 | 54,200 | 1,890 | 15 | 1,929 |
| Mean ................ | | 52,853 | 1,897.1 | ....... | 1,938 |
| Corresponding muzzle velocity.... | | | 1,930.6 | ....... | 1,972.3 |
| 35 grains ......... | 1 | 51,200 | 1,944 | 1 | 1,954 |
| | 2 | 60,200 | 1,990 | 2 | 2,002 |
| | 3 | 53,200 | 1,950 | 3 | 2,010 |
| | 4 | 58,200 | 1,964 | 4 | 1,968 |
| | 5 | 52,200 | 1,955 | 5 | 1,992 |
| | 6 | 48,000 | 1,879 | 6 | 2,010 |
| | 7 | 53,600 | 1,910 | 7 | 1,976 |
| | 8 | 62,200 | 1,996 | 8 | 1,990 |
| | 9 | 57,600 | 1,986 | 9 | 1,992 |
| | 10 | 57,600 | 1,964 | 10 | 2,004 |
| | 11 | 58,800 | 1,986 | 11 | 1,980 |
| | 12 | 54,500 | 1,920 | 12 | 2,004 |

| Charge. | Caliber .30 pressure barrel. | | | Springfield caliber .30 gun. | |
|---|---|---|---|---|---|
| | Shot. | Pressure. | Velocity, instrumental. | Shot. | Velocity, instrumental. |
| 35 grains.......... | 13 | 60,200 | 1,968 | 13 | 2,002 |
| | 14 | 49,000 | 1,960 | 14 | 1,988 |
| | 15 | 54,000 | 1,952 | 15 | 2,010 |
| Mean.................. | | 55,900 | 1,954.9 | ....... | 1,992.1 |
| Corresponding muzzle velocity.... | | | 1,989.5 | ....... | 2,027.2 |
| 36 grains......... | 1 | 63,200 | 2,008 | 1 | 2,070 |
| | 2 | 63,000 | 2,012 | 2 | 2,054 |
| | 3 | 61,900 | 2,016 | 3 | 2,056 |
| | 4 | 65,000 | 2,036 | 4 | 2,036 |
| | 5 | 65,100 | 2,034 | 5 | 2,048 |
| | 6 | 62,400 | 2,012 | 6 | 2,036 |
| | 7 | 59,600 | 2,004 | 7 | 2,078 |
| | 8 | 62,200 | 1,996 | 8 | 2,022 |
| | 9 | 64,000 | 2,032 | 9 | 2,048 |
| | 10 | 58,600 | 2,012 | 10 | 2,060 |
| Mean.................. | | 62,530 | 2,015.2 | ....... | 2,050.8 |
| Corresponding muzzle velocity.... | | | 2,050.7 | ....... | 2,087 |

All the velocities given as instrumental are at 50 feet from the muzzle. The muzzle velocities are computed therefrom by the formula and tables of Capt. Ingalls. In all cases the bullet was the new experimental one, lead with copper jacket, weight 230 grains. It will be noticed that the velocities obtained in the rifle exceeds those, for corresponding charges, in the pressure barrel by 35 to 45 feet. This diminution of velocity with the pressure barrel has of course long been known to exist and is occasioned by the small escape of gas past the piston. The exact difference had not previously been determined for the small-caliber ammunition; that it is so small permits the inference to be drawn that the pressures experienced in the gun can only slightly exceed those recorded in the pressure barrel.

A report of trial of this Wetteren powder was previously rendered under date of April 11, 1891. The powder then gave with 36 grains a pressure of 47,720 pounds and an instrumental velocity of 1,876 feet; for 37 grains the pressure was 54,870 pounds; the velocity, 1,952.5 feet. The powder had about ten days previously reached New York after shipment across the Atlantic; it was tested here on the same day it was received.

In the three and one-half weeks that have since elapsed the powder has been kept in a warm, dry atmosphere, and has apparently so far changed in its power that a charge less by 2 or 3 grains will now produce about the same pressure and velocity corresponding to the greater charge nearly a month ago. If these conclusions are substantiated by additional trials after further exposure of the powder, it would be advisable to reduce to, say, 33 grains the charge for the cartridges to be used by the Board on Magazine Arms.

I understand that only 3,000 of these cartridges have as yet been loaded; that number will answer for the tests to be made by the Board during the next fortnight, and as I do not anticipate a sufficient number of other guns will be ready to make worth while a meeting for trials, after the coming one, before early in July, there will be ample time to decide upon the proper charge for the additional amount of ammunition that will ultimately be required.

Very respectfully, your obedient servant,

S. E. BLUNT,
*Captain, Ord. Dept., U. S. Army.*

(3057-'91.)

## No. 6.

## THIRD REPORT ON WETTEREN SMOKELESS POWDER.

SPRINGFIELD ARMORY,
*Springfield, Mass., June 19, 1891.*

Col. A. R. BUFFINGTON,
*Commanding:*

COLONEL: In accordance with your verbal directions, I have the honor to submit the following report of additional trials, just completed, of the Wetteren smokeless powder.

Previous reports were rendered on April 11, 1891, and May 8, 1891. As formerly stated, the powder, about ten days prior to the date of the first report, had arrived in New York after shipment across the Atlantic. It was then forwarded here and tested the day it was received.

Up to May 8, and also since that date to the present, the powder has been kept loosely wrapped in paper in a dry, warm atmosphere. It now gives results as stated below:

*Wetteren smokeless powder.*

| Charge. | Shot. | Pressure. | Velocity, instrumental. | Charge. | Shot. | Pressure. | Velocity, instrumental. |
|---|---|---|---|---|---|---|---|
| | | *Pounds.* | *Feet.* | | | *Pounds.* | *Feet.* |
| 33 grains...... | 1 | 46,000 | 1,766 | 35 grains...... | 1 | 55,000 | 1,916 |
| | 2 | 46,000 | Lost. | | 2 | 58,200 | 1,898 |
| | 3 | 46,600 | 1,811 | | 3 | 59,200 | 1,958 |
| | 4 | 44,800 | 1,772 | | 4 | 55,200 | 1,910 |
| | 5 | 51,200 | 1.836 | | 5 | 57,700 | 1,910 |
| | 6 | 48,400 | 1,852 | | 6 | 55,200 | 1,938 |
| | 7 | 49,400 | 1,835 | | 7 | 55,200 | Lost. |
| | 8 | 49,400 | 1,842 | | 8 | 50,700 | 1,902 |
| | 9 | 49,400 | 1,854 | | 9 | 56,200 | 1,952 |
| | 10 | 48,900 | 1,810 | | 10 | 56,200 | 1,956 |
| Mean ............. | | 48,010 | 1,819.8 | Mean ............. | | 55,880 | 1,926.7 |
| Muzzle............ | | ............ | 1,852.0 | Muzzle............ | | ............ | 1,960.7 |
| Extreme variation. | | 6,400 | 88 | Extreme variation. | | 8,500 | 60 |
| 34 grains...... | 1 | 53,200 | 1,840 | 36 grains...... | 1 | 63,400 | 1,998 |
| | 2 | 48,400 | 1,835 | | 2 | 65,100 | 1,972 |
| | 3 | 52,200 | 1,849 | | 3 | 58,200 | 1,934 |
| | 4 | 52,200 | 1,860 | | 4 | 62,400 | 1,994 |
| | 5 | 52,200 | 1,855 | | 5 | 58,400 | 1,966 |
| | 6 | 52,200 | 1,855 | | 6 | 57,200 | 1,952 |
| | 7 | 51,400 | 1,871 | | 7 | 62,800 | 1,982 |
| | 8 | 51,400 | 1,878 | | 8 | 62,400 | 2,034 |
| | 9 | 51,200 | 1,871 | | 9 | 62,500 | 2,006 |
| | 10 | 50,700 | 1,810 | | 10 | 57,200 | 1,978 |
| Mean ............. | | 51,510 | 1,852.4 | Mean ............. | | 60,960 | 1,981.6 |
| Muzzle............ | | ............ | 1,885.1 | Muzzle............ | | ............ | 2,016.6 |
| Extreme variation. | | 4,800 | 68 | Extreme variation. | | 7,900 | 100 |

In this firing the caliber .30 pressure barrel was used, the bullet, weight 230 grains, was of lead with copper jacket, and the velocities given as instrumental are at 50 feet from the muzzle. From these the muzzle velocities are computed by the tables and formula of Capt. Ingalls, of the artillery.

These results are about the same as those obtained at the time of the last report, and would indicate that the effect upon the powder of the ocean voyage had been eradicated by May 8, after a month here in storage, and that no material change has since occurred.

The conclusion foreshadowed in my last report is now inevitable, and it would seem that to keep the pressure in the vicinity of 50,000 pounds, which is deemed most appropriate for the tests of the Board on Magazine Arms, that the charge should not exceed 34 grains, which it is therefore recommended be established for all cartridges hereafter prepared for the Board.

This charge gives a muzzle velocity in the pressure barrel of 1,885 feet, but from previous firings it has been determined that about 40 feet should be added for the velocity that would be obtained in the 0.30 caliber rifle itself, which may therefore be assumed to be about 1,925 feet.

To determine the effect of moisture and of heat upon the powder, one lot was exposed in an atmosphere rendered moist by escaping steam eight hours a day for two days, and another lot was exposed eight hours a day for four days to a dry heat of about 150°. During this period, especially while the first lot was being exposed to moisture, the external temperature was unusually hot, a maximum of 95° and 97° being reached.

The results obtained are exhibited in the following table:

*Wetteren powder.*

| Charge. | Exposed to moisture. | | | Charge. | Exposed to heat. | | |
|---|---|---|---|---|---|---|---|
| | Shot. | Pressure. | Velocity, instrumental. | | Shot. | Pressure. | Velocity, instrumental. |
| | | *Pounds.* | *Feet.* | | | *Pounds.* | *Feet.* |
| 33 grains...... | 1 | 50,800 | 1,866 | 33 grains...... | 1 | 48,400 | 1,858 |
| | 2 | 43,600 | Lost | | 2 | 44,500 | 1,791 |
| | 3 | 45,400 | 1,828 | | 3 | 48,400 | 1,826 |
| | 4 | 45,400 | 1,802 | | 4 | 42,800 | 1,781 |
| | 5 | 49,900 | 1,866 | | 5 | 46,600 | 1,830 |
| | 6 | 53,000 | 1,870 | | 6 | 41,800 | 1,716 |
| | 7 | 44,600 | 1,786 | | 7 | 41,800 | 1,755 |
| | 8 | 47,800 | 1,806 | | 8 | 36,400 | 1,684 |
| | 9 | 46,100 | 1,818 | | 9 | 44,800 | 1,766 |
| | 10 | 42,300 | 1,800 | | 10 | 37,200 | 1,735 |
| Mean.................... | | 46,890 | 1,826.8 | Mean................. | | 43,270 | 1,774.2 |
| Muzzle.......................... | | .................. | 1,859.1 | Muzzle.......................... | | .................. | 1,805.5 |
| Extreme variation. | | 10,700 | 84 | Extreme variation. | | 12,000 | 174 |
| 36 grains...... | 1 | 55,200 | 1,980 | 36 grains...... | 1 | 56,300 | 1,962 |
| | 2 | 54,200 | 1,980 | | 2 | 54,200 | 1,964 |
| | 3 | 60,200 | 2,058 | | 3 | 52,200 | 1,938 |
| | 4 | 64,400 | 1,992 | | 4 | 54,600 | 1,944 |
| | 5 | 61,200 | 2,000 | | 5 | 52,800 | 1,928 |
| | 6 | 64,500 | 1,996 | | 6 | 52,200 | 1,875 |
| | 7 | 58,200 | 1,970 | | 7 | 49,400 | 1,890 |
| | 8 | 53,700 | 1,986 | | 8 | 44,800 | 1,873 |
| | 9 | 52,200 | 1,976 | | 9 | 45,000 | 1,862 |
| | 10 | 60,800 | 1,980 | | 10 | 50,400 | 1,890 |
| Mean.................... | | 58,460 | 1,991.8 | Mean................. | | 51,190 | 1,912.6 |
| Muzzle.......................... | | .................. | 2,027.0 | Muzzle.......................... | | .................. | 1,946.4 |
| Extreme variation. | | 12,300 | 88 | Extreme variation. | | 11,500 | 102 |

Referring to the test of the powder in its normal condition, it will be observed that the exposure to moisture did not materially affect the powder; the pressures observed are, to be sure, very slightly less and the velocities a very little greater, but additional shots might have made this small discrepancy less evident.

The tendency of nitrated substances, such as gun cotton, nitroglycerin, etc. (which undoubtedly in some form enter this powder), to decompose when the temperature reaches about 160° is exemplified in the case of the powder exposed to heat. It was intended that the heat should be kept at about 150°, but it occasionally slightly exceeded that limit, and consequently the results obtained show a slight loss in both pressure and velocity, being for the latter about 2½ to 3½ per cent, as compared with the unexposed powder. These changes are very slight compared with the modifications, under similar treatment, observed in some Nobel powder lately tested and show the Wetteren to be a more stable compound.

In preparing the cartridges for experimental firing at this armory all work is done by hand, each charge being carefully weighed before loading. Such a method of loading in quantity would not, of course, be practicable, but the considerable variations in velocity produced by only moderate changes in the charge of these smokeless powders emphasizes the necessity for all the accuracy attainable.

To compare the armory hand work with the cartridges loading in greater quantity at the Frankford Arsenal twenty shots were fired with ammunition loaded there early this month and just received here. These cartridges it was understood contained 36 grains of Wetteren powder. The following velocities were found:

| Shot. | Velocity, instrumental. | Shot. | Velocity, instrumental. | Shot. | Velocity, instrumental. |
|---|---|---|---|---|---|
| | *Feet.* | | *Feet.* | | *Feet.* |
| 1 | 1,952 | 10 | 1,918 | 19 | 1,936 |
| 2 | 1,930 | 11 | 1,862 | 20 | 1,938 |
| 3 | 1,976 | 12 | 1,929 | | |
| 4 | 1,944 | 13 | 1,948 | Mean | 1,923.4 |
| 5 | 1,950 | 14 | 1,835 | Muzzle | 1,957.4 |
| 6 | 1,912 | 15 | 1,922 | Extreme variation | 141 |
| 7 | 1,946 | 16 | 1,936 | | |
| 8 | 1,912 | 17 | 1,936 | | |
| 9 | 1,934 | 18 | 1,852 | | |

Referring to the first table of this report it is seen that 36 grains in the armory cartridge gave in the pressure barrel an instrumental velocity of 1,981.6, corresponding to 2,016.6 feet muzzle velocity in the pressure barrel, or about 2,055 feet muzzle velocity in the gun; that is 100 feet more than obtained with the cartridge having the same charge as loaded at Frankford Arsenal.

In the execution of the firing given in this report I have been assisted by Lieut. F. P. Peck, Ordnance Department.

Very respectfully, your obedient servant,

S. E. BLUNT,
*Captain, Ord. Dept., U. S. Army.*

(4019-'91.)

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## No. 7.

SPRINGFIELD ARMORY,
*Springfield, Mass., June 5, 1891.*

Col. A. R. BUFFINGTON,
*Commanding:*

COLONEL: In accordance with your verbal directions I have the honor to make the following report of the trials of some Nobel smokeless powder:

This powder was received from the works of the Rhenisch-Westphalia Explosives Stock Company. It is in nearly cubical grains, varying from about 0.037 inch to 0.045 inch on an edge; is tough and elastic rather than brittle, and is somewhat gelatinous. The grains are coated with graphite, and have its familiar luster, but when cut, as they readily can be with a knife, the inner surface is seen to be of a dull grayish-brown color. Ignited, unconfined, in the open air the powder burns slowly with an orange blaze tinged with blue or purple and without smoke or distinctive odor. There is no smoke or odor when fired in the gun and but little fouling.

The primers used here, which have ignited charges of other smokeless powders, generally failed with this powder if the charge, which did not entirely fill the shell, had not been settled down next the primer; when that precaution was observed the ignition, however, was prompt.

After a preliminary charge of 30 grains, which gave a pressure of 33,800 pounds with an instrumental velocity of 1,704 feet, the trials were continued with results as given in the following tables:

*Nobel smokeless powder.*

| Charge. | Shot. | Pressure. | Velocity, instrumental. |
|---|---|---|---|
| | | *Pounds.* | *Feet.* |
| 32 grains | 1 | 49, 200 | 1, 862 |
| | 2 | 49, 400 | 1, 862 |
| | 3 | 50, 400 | 1, 898 |
| | 4 | 44, 600 | 1, 852 |
| | 5 | 46, 400 | 1, 850 |
| Mean | | 48, 000 | 1, 864. 8 |
| Muzzle | | | 1, 897. 8 |
| 33 grains | 1 | 53, 200 | 1, 974 |
| | 2 | 51, 000 | 1, 934 |
| | 3 | 50, 400 | 1, 898 |
| | 4 | 54, 200 | 1, 966 |
| | 5 | 50, 400 | 1, 958 |
| | 6 | 54, 200 | 1, 962 |
| | 7 | 52, 200 | 1, 952 |
| | 8 | 57, 800 | 1, 980 |
| | 9 | 52, 700 | 1, 960 |
| | 10 | 53, 000 | 1, 982 |
| | 11 | 58, 200 | 1, 954 |
| | 12 | 54, 200 | 1, 950 |
| | 13 | 55, 200 | 1, 912 |
| | 14 | 58, 700 | 1, 956 |
| | 15 | 51, 200 | 1, 946 |
| | 16 | 47, 800 | 1, 920 |
| | 17 | 55, 700 | 1, 906 |
| | 18 | 59. 100 | 1, 976 |
| | 19 | 57, 600 | 1, 976 |
| | 20 | 57, 200 | 1, 956 |
| Mean | | 54, 200 | 1, 950. 9 |
| Muzzle | | | 1, 985. 4 |
| Extreme variation | | 11, 300 | 84 |
| 34 grains | 1 | 56, 600 | 1, 960 |
| | 2 | 58, 600 | 1, 984 |
| | 3 | 58, 600 | 1, 990 |
| | 4 | 54, 200 | 1, 950 |
| | 5 | 52, 600 | 1, 926 |
| | 6 | 55, 600 | 1, 966 |
| | 7 | 56, 600 | 1, 972 |
| | 8 | 60, 200 | 1, 974 |
| | 9 | 58, 200 | 1, 962 |
| | 10 | 57, 000 | 1, 976 |
| | 11 | 54, 800 | 1, 970 |
| | 12 | 59, 700 | 1, 980 |
| | 13 | 54, 700 | 1, 960 |
| | 14 | 53, 700 | 1, 944 |
| | 15 | 58, 700 | 1, 982 |
| | 16 | 57, 200 | 1, 982 |
| | 17 | 59, 200 | 1, 998 |
| | 18 | 57, 200 | 1, 980 |
| | 19 | 57, 400 | 1, 980 |
| | 20 | 56, 200 | 1, 972 |
| Mean | | 56, 350 | 1, 970. 4 |
| Muzzle | | | 2, 005. 2 |
| Extreme variation | | 7, 600 | 74 |
| 35 grains | 1 | 59, 400 | 2, 020 |
| | 2 | 61, 200 | 2, 062 |
| | 3 | 57, 000 | 2, 028 |
| | 4 | 60, 200 | 2, 042 |
| | 5 | 60, 000 | 2, 012 |
| | 6 | 62, 900 | 2, 050 |
| | 7 | 62, 400 | 2, 032 |
| | 8 | 66, 200 | 2, 058 |
| | 9 | 65, 100 | 2, 044 |
| | 10 | 62, 400 | 2, 054 |
| Mean | | 61, 680 | 2, 040. 2 |
| Muzzle | | | 2, 076. 2 |
| Extreme variation | | 9, 200 | 50 |

In these trials the caliber .30 barrel arranged for determining pressures were used; the bullet (lead with copper jacket) weighed 230 grains, All the velocities given as instrumental are at 50 feet from the muzzle; the muzzle velocities are computed therefrom by the formula and tables of Capt. Ingalls. By previous trials it has been determined that the velocities (when between 1,700 and 2,000 feet) obtained from the pressure barrel are about 40 feet less than those for corresponding charges in the gun; that amount must therefore be added to those recorded above for the velocities that would have been found in the caliber .30, Springfield rifle.

As compared with other powders that have been tested at the armory in the last eighteen months, this Nobel in its ballistic effects is inferior to the Maxim and Houghton, and about on a par with the Wetteren. From the shape of the grain it can be as readily loaded as the Houghton, more easily than the Maxim or Wetteren, but it is more difficult to ignite than either of them, our primers, as has been stated, failing, unless the powder was kept at the base of the shell. This precaution it would be impracticable to continually exercise, and consequently, unless stronger primers were employed, the powder would possess little value for ordinary use.

To determine the effect on the powder of the increase of temperature and of moisture one lot was exposed to a dry heat of 150° eight hours a day for six days, and another lot to an atmosphere rendered moist by escaping steam; the latter was exposed for two days, eight hours each day. In charges of 30, 33, and 35 grains the following results were then obtained:

*Nobel powder.*

| Exposed to moisture. | | | Exposed to heat. | | |
|---|---|---|---|---|---|
| Charge. | Pressure. | Velocity, instrumental. | Charge. | Pressure. | Velocity, instrumental. |
| | *Pounds.* | *Feet.* | | *Pounds.* | *Feet.* |
| 30 grains | 39,000 | 1,733 | 30 grains | 28.600 | 1,561 |
| | 39,500 | 1,727 | | 27,000 | 1,552 |
| | 39,200 | 1,719 | 33 grains | 38,700 | 1,702 |
| 33 grains | 47,200 | 1,903 | 35 grains | 43,800 | 1,797 |
| | 53,400 | 1,908 | | | |
| 35 grains | 56,200 | 2,026 | | | |
| | 53,600 | 2,004 | | | |

Though precaution was observed to avoid misfires by shaking the powder down next the primer, there were thirty-three failures and but eleven successful ignitions (as above) in the forty-four cartridges in which the two lots of powder were made up, and even those that did ignite hung fire in a marked degree. Comparing these results with those given in the preceding table for the powder in its normal condition it will be noticed that apart from the greatly increased difficulty of ignition the effect of moisture was to decrease both pressure and velocity, but only to a moderate extent, while for the powder exposed to a dry heat the pressure and velocity were vastly decreased, the powder undoubtedly losing some of its essential ingredients by evaporation. The moistened powder was soft and less elastic; the dried powder had become brittle. In both the original luster was diminished.

Very respectfully, your obedient servant,

S. E. Blunt,
*Captain, Ord. Dept., U. S. Army.*

(3607–'91.)

# APPENDIX 14.

## *CLAY'S CARTRIDGE SHELL.*

HEADQUARTERS DEPARTMENT OF ARIZONA,
*Los Angeles, Cal., December 31, 1890.*

The CHIEF OF ORDNANCE, U. S. ARMY,
*Washington, D. C.:*

SIR: I have the honor to send you by mail to-day some experimental shells of my own designing, which I would like to have tested, or rather compared, with the ordinary service shell, as regards initial velocity, penetration, recoil, and report. I have had very little opportunity for experimenting with these shells, but what little I have done has satisfied me that the average penetration is greater, the recoil and report *at least* one-third less than with the service shell.

It has been my experience that when the powder is ignited at the rear of the charge more or less of it is blown from the piece unburned. By means of the tube in the shells I send the powder is ignited in front of the charge. It not only gives all the powder a chance to burn, but the small amount contained in the tube being ignited first starts the bullet and makes it take the grooves, without tearing it all to pieces before the main charge is exploded, thereby acting somewhat on the principle of a progressive detonating powder.

If a bottle-shaped shell is to be used in the new small caliber rifle intended for the Army, I believe a tube to ignite the powder in front of the charge would be a valuable adjunct, as it would greatly lessen the recoil and cause all the powder to be burnt, and if a steel bullet is to be used. I believe the jacket would be less liable to strip.

If you consider these shells worth experimenting with please be kind enough to inform me of the result.

Very respectfully, your obedient servant,

T. J. CLAY,
*First Lieutenant, Tenth Infantry,*
*Inspector of Small-Arms Practice.*

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## REPORT UPON LIEUT. CLAY'S CARTRIDGE SHELL.

SPRINGFIELD ARMORY,
*Springfield, Mass., January 28, 1891.*

SIR: In accordance with your verbal directions I have the honor to report as follows upon the trials of the cartridge shell proposed by Lieut. T. J. Clay, Tenth Infantry. The shell differs from the service in that it has a tube 0.19 inch in exterior and 0.10 inch in interior diameter, projecting from the primer socket 1.28 inches into the powder space. The objects as claimed for this device by Leut. Clay are twofold; first, to secure front ignition of the charge, and, second, to obtain a progressive burning of the powder and gradual movement of the bullet by the combustion of that portion of the charge within the tube before the main charge is ignited. The tests for velocity were begun with a charge of 50 grains of powder; this just filled the experimental shell so that the bullet (one of 500 grains) could be seated without compression. Service shells were loaded with a similar charge and the two kinds fired alternately with the following results:

TABLE I.—*Fifty grains—Instrumental velocities.*

| Shot. | Clay experimental shell. | Service shell. |
|---|---|---|
| | *Feet.* | *Feet.* |
| 1 | 1,010 | 1,033 |
| 2 | 1,018 | 1,024 |
| 3 | 1,005 | 1,034 |
| 4 | 1,013 | 1,021 |
| **Mean** | 1,011.5 | 1,028 |

Firing was continued with a charge of 55 grains. With this charge in the Clay shell, if the bullet was seated without any compression of the powder, one cannelure was left exposed. The bullet was, however, forced down until the cartridge became of the standard length. Results were as follows:

TABLE II.—*Fifty-five grains—Instrumental velocities.*

| Shot. | Clay shell. | Service shell. |
|---|---|---|
| | *Feet.* | *Feet.* |
| 1 | 1,038 | 1,054 |
| 2 | 1,072 | 1,072 |
| 3 | 1,071 | 1,065 |
| 4 | 1,077 | 1,061 |
| Mean | 1,069.5 | 1,063 |

Loading the Clay shell with 60 grains exposed two cannelures when no compression was given the powder; before firing the bullet was pushed into the shell to its service position, considerable compression of the charge of course resulted. In the service shell the 60 grains loosely filled it to the base of the bullet without compression of the powder. Results of firing as follows:

TABLE III.—*Sixty grains—Instrumental velocities.*

| Shot. | Clay shell. | Service shell. |
|---|---|---|
| | *Feet.* | *Feet.* |
| 1 | 1,116 | 1,116 |
| 2 | 1,121 | 1,115 |
| 3 | 1,133 | 1,108 |
| 4 | 1,128 | 1,115 |
| Mean | 1,124.5 | 1,113.5 |

While 60 grains appears to be about the practicable limit of the charge in the Clay shell, the service shell permits with less compression of the powder a charge of 70 grains. Charges of that weight were fired with the following velocities (instrumental): 1,254, 1,255, 1,254, 1,257—a mean of 1,255.

All the above firing was done in the service rifle, where the length of chamber compelled the compression which was given the powder with the 55 and 60 grain charges in the Clay shell. To determine what effect, if any, this compression had upon the observed velocities additional firing was done in a Springfield rifle with a chamber 0.3 inch longer than in the service arm. In this chamber, and 60 grains in the Clay shell, the cartridge just filled the chamber and the bullet rested firmly, but without compression on the powder, two cannelures being exposed without the shell, as previously mentioned. Results as follows:

TABLE IV.—*Long-chamber rifle—Instrumental velocities.*

| Shot. | Clay shell, 60 grains. (No compression.) | Service shell, 60 grains. (No compression.) | Service cartridge, 70 grains. |
|---|---|---|---|
| | *Feet.* | *Feet.* | *Feet.* |
| 1 | 1,107 | 1,102 | 1,255 |
| 2 | 1,096 | 1,116 | 1,259 |
| 3 | 1,104 | 1,125 | 1,252 |
| 4 | 1,113 | 1,115 | 1,260 |
| Mean | 1,105 | 1,114.5 | 1,256.5 |

If this table and those preceding it are examined together the following conclusions become evident:

First. If no compression is given the powder equal charges give less velocity in the Clay shell than in the service.

Second. If the powder in the Clay shell is compressed and that in the service is not the higher velocities will be obtained with the Clay shell, the excess becoming greater as the charge and consequent compression is increased, but being, however, always small and unimportant.

Third. With Clay shell filled and powder compressed, service shell filled and powder similarly compressed (no tube being in the way an increased charge is of course permitted), the service shell shows a great excess (about 130 feet) in velocity.

Fourth. As far as velocity is concerned the service shell, therefore, appears much superior to the Clay.

To determine penetration the usual butt of pine boards, 1 inch thick, 1 inch apart, was employed. The long-chambered gun was used and cartridges as in Table IV; that is, 60 grains in the Clay and the same in the service shell, both without compression. Results as below:

TABLE V.—*Penetration.*

| Clay shell. | | Service shell. | |
|---|---|---|---|
| Shot. | Penetration. | Shot. | Penetration. |
| | *Inches.* | | *Inches.* |
| 1 | 16.2 | 1 | 18.0 |
| 2 | 18.0 | 2 | 17.3 |
| 3 | 17.7 | 3 | 17.5 |
| Mean | 17.3 | Mean | 17.6 |

Referring to Table IV it will be noticed that under similar conditions the velocities with the service shell were slightly the greater. Any differences in penetration which might exist would, then, probably be in favor of the service shell, and this is shown to be the case.

No differences were observed in the recovered bullets, they having apparently taken the grooves in an exactly similar manner.

To determine the recoil the Clay shell was loaded with 60 grains and the powder compressed by forcing the bullet down until the cartridge was of standard length; the service shell was also loaded with 60 grains, which, of course, gave no compression; the velocities corresponding to this loading are given in Table III. The recoil was found to be with the Clay shell 8¼ foot pounds, that with the service shell was 8 foot pounds, the slight difference being in the same direction as the corresponding velocities.

Although carefully observed no distinction between the Clay and service shells was noticed in the report.

From these various results the final conclusion is drawn that the claims made by Lieut. Clay for this shell are not confirmed by trial and that the shell is inferior to the service one now in use.

Very respectfully, your obedient servant,

S. E. BLUNT,
*Captain, Ordnance Department.*

Approved. While it was conceded as a truth of theory and practice that ignition in front of a charge would burn more powder and give a small increase of velocity, a principle on which a number of patents for accelerating cartridges are more or less founded, it was thought best to test this particular device so that there could be no question as to its practical value.

A. R. BUFFINGTON,
*Colonel, Ord. Dept., Commanding.*

(95–'91.)

# APPENDIX 15.

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## *PRACTICE FIRING BY THE ARMORY RIFLE CLUB.*

SPRINGFIELD ARMORY,
*Springfield, Mass., July 20, 1891.*

SIR: In accordance with your verbal directions I have the honor to submit the following report of the firing of the Armory Rifle Club for the year ending June 30, 1891:

The object of this practice is to test the firing qualities of the rifles and carbines of current manufacture and to detect if possible any variations from the established standards that may have escaped the observation of the regular inspectors in, more particularly, the lock, sights, and rifling of the barrel.

For this purpose one afternoon in each week during the year, without regard to the state of the weather, whether warm or cold, stormy or fair, has been devoted to the firing of arms taken by chance from the output of the preceding week, and the practice held at some one of the distances, 200, 300, 500, 600, and 800 yards, the particular range for the day being somewhat determined by the condition of the weather in order that the individual judgment of the men or their ability to hold on the target might not have a preponderating influence upon the results.

The targets used and methods of conducting firing have been as prescribed in the firing regulations for small arms which governs in the practice of the Army and the scores made therefore permit of some comparison with those at the different posts. It should not be overlooked, however, that the armory range is mostly over water, is peculiarly difficult, and that the weather this past year, unusually bad on practice days, has rendered the making of high scores a matter requiring an extreme amount of discriminating judgment. The men firing were also entirely unaccustomed to the particular guns used, they having been selected by chance and had only been fired the usual proof shots.

The summary of practice is as follows:

*Practice of the Armory Rifle Club for the year ending June 30, 1891.*

[Ranges 200, 300, 500, 600, and 800 yards.]

| Name. | Number of shots fired. | Total score. | | Per cent. | Average score. |
|---|---|---|---|---|---|
| | | Possible. | Actual. | | |
| L. T. Farnsworth | 475 | 2,875 | 2,053 | 86.44 | 21.61 |
| F. R. Bull | 1,310 | 6,550 | 5,515 | 84.20 | 21.05 |
| S. E. Blunt | 645 | 3,225 | 2,688 | 83.35 | 20.84 |
| S. Bowers | 1,235 | 6,175 | 5,140 | 83.24 | 20.81 |
| J. A. Sterling | 1,450 | 7,250 | 5,986 | 82.57 | 20.64 |
| W. E. Hosmer | 1,040 | 5,200 | 4,229 | 81.33 | 20.33 |
| Club | 6,155 | 30,775 | 25,611 | 83.22 | 20.80 |

The practice was generally held in scores of ten shots each; of these the best at 200 yards were 47 by Mr. Bowers, the same score twice by Mr. Sterling, and a 46 by Mr. Bull and myself.

At 500 yards a 50 was made by Mr. Bowers, 49 twice by Mr. Farnsworth and once by Mr. Sterling, while 48 was frequently reached by the others of the club.

At 600 yards the 47 by Mr. Bowers and Mr. Hosmer and a 46 by myself were the best.

At 800 yards the only really good score was 49 by Mr. Hosmer.

Single scores of 24 were often made and a few of 25 at several ranges. The longest run of consecutive bull's-eyes was one of thirteen at 500 yards by Mr. Farnsworth.

With these good scores some very poor ones were also made, as low as 15 (out of a possible 25) being recorded against each member of the club, and several below 10 also appearing. All of these, as well as the better ones, are included in the preceding tabulated summary.

In addition to the above practice trials were conducted, utilizing the services of the club, or of its individual members, to determine the proper height of front sight for carbines, in which a correction had been suggested, and also to determine the accuracy of fire of various foreign arms.

In the latter experiments the rifles were fired from a fixed rest at the ranges 200, 500, 800, and 1,000 yards, and also with a muzzle rest only, as well as in the ordinary manner governing the other practice of the club. With the muzzle rest, but more especially with the fixed rest, a constant and unvarying aim being secured, the record made should be only that of the particular arm and its ammunition uncomplicated by the inaccuracies or peculiarities of the individual firing. To obtain this result it is, however, essential that the atmospheric conditions during the trial should remain unchanged, the wind very light, or if that feature is not obtainable, the wind being constant in strength and direction.

In ordinary target practice, as the wind changes in direction and intensity, the soldier marksman is instructed to either alter the wind gauge or elevation adjustments of the sight, or else to select such a different point of aim on his target, from shot to shot, as to compensate for the changes in the wind; if he has attained proficiency as a rifle shot he will, even under these adverse circumstances, make a fine score.

In the ordinary practice of the club (firing without artificial rest of any kind), this method has been followed, but with the fixed rest tests it is necessary to eliminate as far as possible the personal equation of the marksman.

But this is not the sole precaution requisite to insure a record exhibiting only the performance of the rifle and its ammunition, for using a fixed rest and an unvarying point of aim, if the shots are fired in a wind not of constant strength the targets obtained will show not only the inaccuracies inherent to the arm and its ammunition, but in addition those produced by the wind acting on the bullet during flight. In a head or rear wind of varying intensity the vertical deviation will then be unduly increased; if the wind is across the range the horizontal deviation will be affected, and as it is these latter winds that alter most the path of the bullet, it is the horizontal deviation that will contain, unless care to eliminate it is observed, an undesired and unintended record of the atmospheric conditions as well as of the shooting capacity of the weapon itself.

As to determine this latter element only is the object of fixed-rest trials at this armory, a particular endeavor was made to fire the shots under similar conditions; with this object the streamers on the rifle range were carefully observed and the piece not discharged until a strength and direction of the wind was repeated similar to that which had obtained during former shots. While this method requires the exercise of some observation and judgment on the part of the person directing the firing it unquestionably gives a truer record of the gun than if the shots had been delivered without delay in any puff of wind that happened to be then blowing.

When these precautions were observed it was found that the mean vertical deviation exceeded the horizontal and that this proportionate excess, but small at the shorter ranges, increased as the distance of the rifle from the target was increased.

That the form of the shot group was elliptical and not circular has long been known, and these trials were therefore mainly of value in confirming with foreign guns that conclusion arrived at abroad as well as in this country with the Springfield rifle.

Very respectfully, your obedient servant,

S. E. BLUNT,
*Captain, Ord. Dept., U. S. Army.*

Approved.

A. R. BUFFINGTON,
*Colonel, Ordnance Department.*

(4789-'91.)

# APPENDIX 16.

## *MANUFACTURE OF CALIBER .30 CARTRIDGES AT FRANKFORD ARSENAL, AND EXPERIMENTS ATTENDING THE SAME.*

FRANKFORD ARSENAL,
*Philadelphia, Pa., August 29, 1891.*

The COMMANDING OFFICER,
*Frankford Arsenal:*

SIR: I have the honor to submit the following progress report on experiments with small-caliber cartridges made subsequent to April 1, 1891:

On the arrival of the Wetteren smokeless powder, in the early part of April, experiments were immediately begun for the purpose of determining the velocity to be obtained with different charges. The .309 bullet of 230 grains was used (Frankford Arsenal, first model), as the new model bullets to be made after the pattern of the model steel bullet furnished from Springfield had not been completed.

Unless otherwise noted, all loading was done by hand at the proof house.

The following results were obtained:

*April 9.*—Charge, 28 grains: Mean of 6 shots, 1,426 feet; greatest velocity, 1,454 feet; least velocity, 1,399 feet.

Charge, 29 grains: Mean of 8 shots, 1,469 feet; greatest velocity, 1,521 feet; least velocity, 1,426 feet.

*April 10.*—Charge, 30 grains: Mean of 10 shots, 1,541 feet; greatest velocity, 1,599 feet; least velocity, 1,489 feet.

Charge, 31 grains: Mean of 10 shots, 1,577 feet; greatest velocity, 1,612 feet; least velocity, 1,536 feet.

Charge, 32 grains: Mean of 8 shots, 1,669 feet; greatest velocity, 1,683 feet; least velocity, 1,605 feet; one bullet stripped its cover and missed second target.

*April 11.*—Charge, 32 grains: Mean of 8 shots, 1,669 feet; greatest velocity, 1,738 feet; least velocity, 1,598 feet.

*April 13.*—Charge, 33 grains: Mean of 9 shots, 1,744 feet; greatest velocity, 1,787 feet; least velocity, 1,705 feet. Accuracy, at 500 yards: Radius circle of shots, 0′.67; mean vertical deviation, 0′.66; mean horizontal deviation, 0′.12; 10 shots.

*April 14.*—Charge, 34 grains: Mean of 8 shots, 1,791 feet; greatest velocity, 1,837 feet; least velocity, 1,749 feet. Accuracy, at 500 yards: Two shots missed target; 1 bullet found with jacket stripped off; target not plotted; 10 shots.

Charge, 35 grains: Mean of 7 shots, 1,867 feet; greatest velocity, 1,905 feet; least velocity, 1,820 feet; mean of 10 shots, 1,858 feet; greatest velocity, 1,885 feet; least velocity, 1,832 feet. Accuracy, at 500 yards: Radius circle of shots, 0′.63; mean vertical deviation, 0′.525; mean horizontal deviation, 0′.35; 10 shots.

Charge, 36 grains: Mean of 7 shots, 1,903 feet; greatest velocity, 1,923 feet; least velocity, 1,877 feet.

As noted above, in a number of cases the copper jacket of the bullet stripped from the lead core in firing. When this happened, the shot usually missed the second target when fired for velocity, or the 500-yard target when fired for accuracy. In the limited experiments previously made this had not happened with the .309 bullet, though its occurrence with the .306 bullet had caused the abandonment of that model. In order to detetermine whether this stripping was influenced by the amount of copper turned over at the base, bullets were prepared with their bases covered with solder.

The following results were obtained:

### *April 15.*

*Accuracy at 500 yards; targets of 10 shots; charge, 36 grains.*

| | Regular base. .309 bullet. | Soldered base. .309 bullet. | Soldered base. .306 bullet. |
|---|---|---|---|
| | *Foot.* | *Foot.* | *Foot.* |
| Radius circle of shots | .67 | .49 | .67 |
| Mean vertical deviation | .49 | .28 | .495 |
| Mean horizontal deviation | .44 | .345 | .45 |

*Charge, 35 grains; .309 bullet; regular base; target of 10 shots.*

| | Foot. |
|---|---|
| Radius circle of shots | .63 |
| Mean vertical deviation | .525 |
| Mean horizontal deviation | .35 |

### *April 16.*

*Accuracy at 500 yards; targets of 10 shots; regular base.*

| | .309 bullet. | .306 bullet. |
|---|---|---|
| | *Foot.* | |
| Radius circle of shots | .68 | Not plotted. 3 shots missed target. |
| Mean vertical deviation | .475 | |
| Mean horizontal deviation | .440 | |

*April 17.*—Thermometer: Wet bulb, 63°; dry bulb, 67°. Barometer, 30.20 inches.

*Accuracy at 500 yards; targets of 10 shots; charge, 36 grains; regular base.*

| | .309 bullet. | .306 bullet. |
|---|---|---|
| | *Foot.* | *Foot.* |
| Radius circle of shots | .61 | .91 |
| Mean vertical deviation | .40 | .68 |
| Mean horizontal deviation | .415 | .53 |

A hollowed-base bullet was now tried in comparison with the other varieties.

*Accuracy at 500 yards; targets of 10 shots.*

| | .309 bullet. Regular base. | .309 bullet. Soldered base. | .309 bullet. Hollowed base. |
|---|---|---|---|
| | *Foot.* | *Foot.* | *Foot.* |
| Radius circle of shots | .75 | .53 | .90 |
| Mean vertical deviation | .533 | .26 | .666 |
| Mean horizontal deviation | .444 | .44 | .483 |

*April 18.*—Thermometer: Wet bulb, 67°; dry bulb, 70°. Barometer, 29.99 inches.

*Charge, 36 grains; soldered base; .309 bullet.*

| | Feet. |
|---|---|
| Mean velocity, 7 shots | 1,972 |
| Greatest velocity | 2,012 |
| Least velocity | 1,942 |

*Charge, 36 grains; soldered base; .306 bullet.*

| | Feet. |
|---|---|
| Mean velocity, 9 shots | 1,943 |
| Greatest velocity | 1,970 |
| Least velocity | 1,894 |

In the above trials the .306 bullet demonstrated its unreliability; the .309 bullet (first model) was shown to strip occasionally, and the soldered-base bullet gave decidedly the best results, both as regards velocity and accuracy. A bullet of this kind is thought, however, to be objectionable to manufacture, and it was laid aside for the present. The new (second model) .309 bullet, made after steel pattern bullet furnished from Springfield, now being ready, experiments were begun with it.

*April 21.*—Thermometer: Wet bulb, 63°; dry bulb, 71°. Barometer, 30.26 inches.

*Charge, 36 grains; second model .309 bullet.*

| | Feet. |
|---|---|
| Mean velocity, 10 shots | 1,921 |
| Greatest velocity | 1,936 |
| Least velocity | 1,908 |

*April 23.*—Thermometer: Wet bulb, 67°; dry bulb, 76°. Barometer, 29.6 inches.

*Charge, 36 grains; second model .309 bullet; machine loaded at shop.*

| | Feet. |
|---|---|
| Mean velocity, 10 shots | 1,741 |
| Greatest velocity | 1,825 |
| Least velocity | 1,657 |

Another bullet was devised, having the copper spun over so as to almost entirely cover the base. Otherwise it was identical with the second model .309 bullet. This was known as the spun-base bullet.

*Charge, 36 grains; spun-base bullet; machine loaded at shop.*

| | Feet. |
|---|---|
| Mean velocity, 10 shots | 1,805 |
| Greatest velocity | 1,855 |
| Least velocity | 1,744 |

*Accuracy at 500 yards; targets of 10 shots; second model .309 bullet used; 36 grains charge; machine loaded in shop.*

| | Regular base. | Spun base. |
|---|---|---|
| | *Feet.* | *Foot.* |
| Radius circle of shots | .99 | .77 |
| | 1.05 | .72 |
| | 1.14 | ........... |
| Mean vertical deviation | .86 | ........... |
| | .90 | .48 |
| | .75 | .59 |
| Mean horizontal deviation | .41 | ........... |
| | .48 | .51 |
| | .53 | .375 |

*Charge, 36 grains; machine loaded in shop; second model .309 bullet.—Even shots, spun base; odd shots, regular base.*

| | Feet. |
|---|---|
| Mean of even shots (five) | 1,833 |
| Mean of odd shots (five) | 1,771 |

*April 24.*—Thermometer: Wet bulb, 67°; dry bulb, 76°. Barometer, 29.60 inches.

*Ten shots; charge, 36 grains; second model .309 bullet.—Odd shots loaded by hand at proof house; even shots loaded by machine at shop.*

| | Feet. |
|---|---|
| Mean of odd shots | 1,867 |
| Mean of even shots | 1,751 |

*April 25.*—Thermometer: Wet bulb, 65°; dry bulb, 77°. Barometer, 29.96 inches.

Five hundred grains of the powder had been exposed for twenty-four hours to a heat of 145° F. Loss in weight, 3½ per cent. Cartridges were made up from this powder, using a 36-grain charge and the first model .309 bullet.

| | Feet. |
|---|---|
| Mean of 9 shots | 1,954 |
| Greatest velocity | 1,992 |
| Least velocity | 1,900 |

Three bullets stripped and missed second target.

Five hundred grains of the powder had been placed in water for twenty-four hours and dried in the sun. Cartridges were made up from this powder, using a 36-grain charge and the first model .309 bullet.

| | Feet. |
|---|---|
| Mean of 7 shots | 1,661 |
| Greatest velocity | 1,677 |
| Least velocity | 1,633 |

Three bullets stripped.

Five hundred grains of powder had been placed for twenty-four hours on a rack above a vessel of water. Cartridges were made up from this powder, using a 36-grain charge and the first model .309 bullet.

| | Feet. |
|---|---|
| Mean of 10 shots | 1,701 |
| Greatest velocity | 1,780 |
| Least velocity | 1,637 |

*April 27.*—Thermometer: Wet bulb, 54°; dry bulb, 62°. Barometer, 29.60 inches.

The cartridge case was partially filled with solder, so that a charge of 32 grains would receive 0.15 compression.

| | Feet. |
|---|---|
| Mean of 7 shots | 1,683 |
| Greatest velocity | 1,730 |
| Least velocity | 1,629 |
| Velocity with same charge in ordinary case, April 11 | 1,669 |

Further experiments on the effect of compression on the powder will be made.

No stripping having been developed with the new second model .309 bullet, it was decided for purposes of comparison to fire several shots for velocity, using the spun base bullet, the second model .309 bullet, and a further modified bullet, having more copper turned over at the base, known as third model .309 bullet. This last was a compromise between the ordinary base and the spun base. It was sought also to determine the practicability of machine loading.

*April 30.*—Thermometer: Wet bulb, 63°; dry bulb, 79°. Barometer, 29.75 inches.

*Charge, 36 grains; machine-loaded at shop; second model .309 bullet.*

| | Feet. |
|---|---|
| Mean of 50 shots | 1,745.8 |
| Greatest velocity | 1,807 |
| Least velocity | 1,690 |

*May 1.*—Thermometer: Wet bulb, 63°; dry bulb, 79°. Barometer, 29.75 inches.

*Charge, 36 grains; machine-loaded at shop; second model .309 bullet.*

| | Feet. |
|---|---|
| Mean of 50 shots | 1,742.2 |
| Greatest velocity | 1,795. |
| Least velocity | 1,652. |

*Charge, 36 grains; machine-loaded at shop; spun base .309 bullet.*

| | Feet. |
|---|---|
| Mean of 50 shots | 1,762.8 |
| Greatest velocity | 1,853. |
| Least velocity | 1,645. |

*Charge, 36 grains; machine-loaded at shop; third model .309 bullet.*

| | Feet. |
|---|---|
| Mean of 50 shots | 1,772.7 |
| Greatest velocity | 1,876. |
| Least velocity | 1,647. |

On inspection of a large number an extreme variation of more than 2 grains was found to exist in the machine-loaded charges. As the above trials show, the variations of velocity with this manner of loading were too extreme to allow of its adoption. None of the bullets stripped, and it was resolved to adopt the third model .309 bullet, as being more convenient for manufacture than the spun-base model, while giving more security against stripping than the second model .309 bullet.

*May 5.*—Thermometer: Wet bulb, 40°; dry bulb, 46°. Barometer, 30.04 inches.

*Charge, 36 grains; third model .309 bullet; powder measured by machine in loading at shop.*

| | Feet. |
|---|---|
| Mean of 10 shots | 1,755 |
| Greatest velocity | 1,838 |
| Least velocity | 1,658 |

The variation of velocity obtained was too great to encourage further experiments. It was decided to load all cartridges for use by Magazine Gun Board in future by hand at shop.

*Charge, 36 grains; first model .309 bullet.*

| | Feet. |
|---|---|
| Mean of 8 shots | 1,832 |
| Greatest velocity | 1,847 |
| Least velocity | 1,810 |

*May 6.*—Thermometer: Wet bulb, 43°; dry bulb, 51°. Barometer, 29.98 inches.

*Charge, 36 grains; third model .309 bullet; hand loaded at shop.*

| | Feet. |
|---|---|
| Mean of 9 shots | 1,805 |
| Greatest velocity | 1,840 |
| Least velocity | 1,769 |

*Charge, 36 grains; third model .309 bullet.*

| | Feet. |
|---|---|
| Mean of 10 shots | 1,865 |
| Greatest velocity | 1,930 |
| Least velocity | 1,890 |

*May 7.*—Thermometer: Wet bulb, 42°; dry bulb, 45°. Barometer, 29.99 inches.

*Charge, 36 grains; hand-loaded at shop; third model .309 bullet.*

| | Feet. |
|---|---|
| Mean of 10 shots | 1,843 |
| Greatest velocity | 1,890 |
| Least velocity | 1,794 |

*May 8.*—Thermometer: Wet bulb, 55°; dry bulb, 66°. Barometer, 30.14 inches.

| | Feet. |
|---|---|
| Mean velocity | 1,801 |
| Greatest velocity | 1,880 |
| Least velocity | 1,770 |

In all these trials under the same conditions greater velocity was obtained with the cartridges loaded at the proof house. The loading there was done more slowly and the powder better settled into the case. The effect of size of grain on the velocity was very marked, and the irregularity in the size of grain in the Wetteren powder is no doubt a primary cause of the great variations of velocity. Some of the powder was sieved through a sieve of 0.06 inch mesh and charges of 36 grains with a third model .309 bullet fired.

| | Feet. |
|---|---|
| Mean of 5 shots | 2,065 |
| Greatest velocity | 2,090 |
| Least velocity | 2,024 |

*May 9.*—Thermometer: Wet bulb, 66°; dry bulb, 80°. Barometer, 29.96 inches.

*Charge, 36 grains; third model .309 bullet; loaded by hand at shop.*

| | Feet. |
|---|---|
| Mean of 10 shots | 1,810 |
| Greatest velocity | 1,862 |
| Least velocity | 1,777 |

*May 12.*—Thermometer: Wet bulb, 60°; dry bulb, 67°. Barometer, 30.05 inches.

*Charge, 36 grains; third model .309 bullet; loaded by hand at shop May 11.*

| | Feet. |
|---|---|
| Mean of 10 shots | 1,794 |
| Greatest velocity | 1,864 |
| Least velocity | 1,752 |

*Same loaded by hand at shop May 12.*

| | Feet. |
|---|---|
| Mean of 10 shots | 1,854 |
| Greatest velocity | 1,888 |
| Least velocity | 1,810 |

*May 22.*—Thermometer: Wet bulb, 77°; dry bulb, 89°. Barometer, 29.77 inches. Carbine ammunition, .45 caliber; charge, 54 grains of black powder; weight of bullet, 405 grains. Fired in Springfield rifle, caliber .45. Velocities (3 shots), 1,251, 1,243, 1,235; mean, 1,243 feet.

Same except charge, 54 grains of Wetteren smokeless powder, 1,838, 1,901, 1,866; mean, 1,868 feet.

*June 8.*—Thermometer: Wet bulb, 62°; dry bulb, 67°. Barometer, 30.14 inches. Charge, 36 grains; third model .309 bullet. Loaded by hand at shop. Sample of current manufacture. Mean of 10 shots, 1,842 feet; extreme variation, 92 feet.

*June 20.*—Thermometer: Wet bulb, 69°; dry bulb, 74°. Barometer, 29.88 inches. Charge, 36 grains; third model .309 bullet. Loaded by hand at shop. Sample of current manufacture. Mean of 10 shots, 1,761 feet; extreme variation, 112 feet.

*June 22.*—Thermometer: Wet bulb, 77°; dry bulb, 89°. Barometer, 29.77 inches. Charge, 36 grains; third model .309 bullet. Loaded by hand at shop. Sample of current manufacture. Mean of 10 shots, 1,766 feet; extreme variation, 62 feet.

*June 23.*—Thermometer: Wet bulb, 78°; dry bulb, 89°. Barometer, 29.86 inches. Charge, 36 grains; third model .309 bullet. Loaded by hand at shop. Sample of current manufacture. Mean of 10 shots, 1,779 feet; extreme variation, 103 feet.

*Charge, 35 grains; third model .309 bullet; Maxim smokeless powder.*

| | Feet. |
|---|---|
| Mean of 5 shots | 1,892.5 |
| Greatest velocity | 1,921 |
| Least velocity | 1,875 |

Two bullets stripped and missed the second target. The velocity obtained with this powder at Springfield was 1,937 feet. The following pressures were obtained, using the English pressure gauge: Pounds per square inch, 50,700, 50,000, 49,100, 50,000, 49,500; mean, 49,900.

*June 26.*—Thermometer: Wet bulb, 73°; dry bulb, 83°. Barometer, 29.9 inches.

Some powder was taken from a barrel not previously opened, and cartridges made up from it were fired in comparison with those made up with powder that had been for some time in the proof house.

*Charge, 34 grains; third model .309 bullet used.*

| | Feet. |
|---|---|
| Mean of 8 shots with cartridges loaded with powder from new barrel | 1,711 |
| Greatest velocity | 1,738 |
| Least velocity | 1,665 |
| (One bullet stripped and missed second target.) | |
| Mean of 8 shots with cartridges loaded with powder from proof house | 1,714 |
| Greatest velocity | 1,744 |
| Least velocity | 1,669 |

One bullet stripped and missed second target.

The strippings above recorded were entirely unexpected, as several hundred rounds had been previously fired without a single stripping being noted. Investigation failed to develop any variation in manufacture which could account for the above occurrence. The quality of the jacket metal was apparently unaltered and the treatment of it the same, etc.

Experiments were then made with cartridge cases, the necks of which had been given an extra anneal, as it was suggested that the stripping might have been caused by the neck not opening to the pressure of the gas. The effect of crimping the bullet was also tested.

*June 27.*—Thermometer: Dry bulb, 81°; wet bulb, 75°. Barometer, 29.70 inches.

*Charge, 36 grains; extra annealed cases, not crimped.*

| | Feet. |
|---|---|
| Mean of 8 shots | 1,791 |
| Greatest velocity | 1,813 |
| Least velocity | 1,778 |

Two bullets stripped and missed second target.

*Charge, 36 grains; third model .309 bullet; extra annealed case, crimped.*

| | Feet. |
|---|---|
| Mean of 10 shots | 1,804 |
| Greatest velocity | 1,828 |
| Least velocity | 1,769 |

*June 30.*—Thermometer: Wet bulb, 72°; dry bulb, 78°. Barometer, 29.86 inches.

*Charge, 36 grains; third model .309 bullet; extra annealed case, not crimped.*

| | Feet. |
|---|---|
| Mean of 10 shots | 1,804 |
| Greatest velocity | 1,840 |
| Least velocity | 1,767 |

*Same as above, but bullet crimped.*

| | Feet. |
|---|---|
| Mean of 10 shots | 1,806 |
| Greatest velocity | 1,826 |
| Least velocity | 1,736 |
| Mean of 15 shots | 1,857 |
| Greatest velocity | 1,892 |
| Least velocity | 1,819 |

Three bullets stripped and missed second target.

*July 3.*—Thermometer: Wet bulb, 68°; dry bulb, 72°. Barometer, 29.84 inches.

*Charge, 36 grains; third model .309 bullet, with hollowed base; weight, 225 grains.*

| | Feet. |
|---|---|
| Mean of 10 shots | 1,804 |
| Greatest velocity | 1,838 |
| Least velocity | 1,772 |

One bullet stripped and missed second target.

*July 6.*—Thermometer: Wet bulb, 64°; dry bulb, 78°. Barometer, 29.97 inches.

*Charge, 34 grains; third model .309 bullet.*

| | Feet. |
|---|---|
| Mean of 17 shots | 1,700 |
| Greatest velocity | 1,746 |
| Least velocity | 1,662 |

Three bullets stripped and missed second target.

*Accuracy at 500 yards—Target of 10 shots.*

| | Feet. |
|---|---|
| Radius circle of shots | 1.09 |
| Mean vertical deviation | .91 |
| Mean horizontal deviation | .46 |

*July 8.*—Thermometer: Wet bulb, 62°; dry bulb, 63°. Barometer, 29.90 inches.

*Charge, 36 grains; spun-base bullet.*

| | Feet. |
|---|---|
| Mean of 20 shots | 1,777 |
| Greatest velocity | 1,833 |
| Least velocity | 1,744 |

*July 9.*—Thermometer: Wet bulb, 64°; dry bulb, 72°. Barometer, 30 inches.

*Charge, 36 grains; spun-base bullet.*

| | Feet. |
|---|---|
| Mean of 11 shots | 1,757 |
| Greatest velocity | 1,820 |
| Least velocity | 1,702 |

*Charge, 34 grains; third model .309 bullet.*

| | Feet. |
|---|---|
| Mean of 11 shots | 1,705 |
| Greatest velocity | 1,733 |
| Least velocity | 1,684 |

*Charge, 36 grains; spun-base bullet.*

| | Feet. |
|---|---|
| Mean of 29 shots | 1,749 |
| Greatest velocity | 1,792 |
| Least velocity | 1,685 |

One bullet stripped and missed second target.

*Charge, 34 grains; third model .309 bullet.*

| | Feet. |
|---|---|
| Mean of 7 shots | 1,732 |
| Greatest velocity | 1,761 |
| Least velocity | 1,695 |

*Same, except bullets dipped in melted Japan wax.*

| | Feet. |
|---|---|
| Mean of 7 shots | 1,788 |
| Greatest velocity | 1,818 |
| Least velocity | 1,764 |

The results of this day's firing showed that the spun-base bullet also stripped occasionally, and indicated that dipping the bullet increased the velocity materially.

*July 10.*—Thermometer: Wet bulb, 64°; dry bulb, 75°. Barometer, 30.23 inches.

*Charge, 36 grains; third model .309 bullet.*

| | Feet |
|---|---|
| Mean of 9 shots | 1,770 |
| Greatest velocity | 1,806 |
| Least velocity | 1,701 |

One bullet stripped and missed second target.

*Same, but bullets dipped in melted Japan wax.*

| | Feet. |
|---|---|
| Mean of 10 shots | 1,822 |
| Greatest velocity | 1,835 |
| Least velocity | 1.805 |

This result confirmed the experiment of the previous day.

*Accuracy at 500 yards.—36-grain charge; covered base bullet.*

| | Foot. |
|---|---|
| Radius circle of shots | .52 |
| Mean vertical deviation | .36 |

*Charge, 36 grains; third model .309 bullet.*

| | Foot. |
|---|---|
| Radius circle of shots | .56 |
| Mean vertical deviation | .42 |

*Charge, 36 grains; third model .309 bullet dipped in wax.*

| | Foot. |
|---|---|
| Radius circle of shots | .44 |
| Mean vertical deviation | .33 |

*July 14.*—Thermometer: Wet bulb, 77°; dry bulb, 86°. Barometer, 30 inches.

Experiments made with bullets of different compositions. The bullets used were all copper jacketed and of the third model .309.

*Bullets containing 100 per cent lead.*

| | Feet. |
|---|---|
| Mean of 20 shots | 1,799 |
| Greatest velocity | 1,835 |
| Least velocity | 1,772 |

*Bullets containing 97 per cent lead and 3 per cent antimony.*

| | Feet. |
|---|---|
| Mean of 18 shots | 1,811 |
| Greatest velocity | 1,850 |
| Least velocity | 1,759 |

Two bullets stripped and missed second target; 36-grain charge.

*Bullets containing 95 per cent lead and 5 per cent antimony.*

| | Feet. |
|---|---|
| Mean of 20 shots | 1,788 |
| Greatest velocity | 1,853 |
| Least velocity | 1,756 |

*July 15.*—Thermometer: Wet bulb, 78°; dry bulb, 86°. Barometer, 29.9 inches.

*Charge, 36 grains; bullets containing 100 per cent lead.*

| | Feet. |
|---|---|
| Mean of 55 shots | 1,785 |
| Greatest velocity | 1,830 |
| Least velocity | 1,719 |

*Bullets containing 97 per cent lead and 3 per cent antimony.*

| | Feet. |
|---|---|
| Mean of 53 shots | 1,803 |
| Greatest velocity | 1,898 |
| Least velocity | 1,657 |

Two bullets stripped and missed second target.

*July 16.*

*Accuracy at 500 yards; targets of 10 shots each; charge, 36 grains.*

| | Radius circle of shots. | Mean vertical deviation. |
|---|---|---|
| | *Foot.* | *Foot.* |
| Bullets 100 per cent lead | .62 | .515 |
| | .54 | .295 |
| | .77 | .520 |
| Bullets 97 per cent lead, 3 per cent antimony | .56 | .47 |
| | .87 | .69 |
| | .47 | .335 |
| Bullets 95 per cent lead, 5 per cent antimony | .50 | .360 |
| | .81 | .690 |
| | .68 | .480 |

*July 17.*—Thermometer: Wet bulb, 70°; dry bulb, 82°. Barometer, 30.10 inches.

In order to try the effect of base lubrication on the velocity, cartridges were loaded using a disk of Japan wax as a base lubricant in addition to the lubricant in the cannelures. The shortness of the neck of the present cartridge case prevented the lubricating disk being placed in the ordinary position in the neck of the shell and it had to be placed in the body of the shell, resting on a pasteboard wad, which rested on the powder.

*Charge, 36 grains; third model .309 bullet.*

| | Feet. |
|---|---|
| Greatest velocity | 1,786 |
| Least velocity | 1,738 |
| Mean of 8 shots | 1,766 |

Two bullets stripped and missed second target.

*Same, using base lubrication.*

| | Feet. |
|---|---|
| Mean of 9 shots | 1,829 |
| Greatest velocity | 1,851 |
| Least velocity | 1,808 |

One bullet stripped and missed second target.

*Charge, 36 grains; third model .309 bullet.*

| | Feet. |
|---|---|
| Mean of 7 shots | 1,763 |
| Greatest velocity | 1,784 |
| Least velocity | 1,748 |

*Same, using base lubrication.*

| | Feet. |
|---|---|
| Mean of 7 shots | 1,855 |
| Greatest velocity | 1,878 |
| Least velocity | 1,835 |

These results indicated a decided increase in velocity, due to base lubrication.

*July 18.*—Thermometer: Wet bulb, 74°; dry bulb, 77°. Barometer, 29.86 inches.

*Charge, 36 grains; third model .309 bullet (94 per cent lead and 6 per cent antimony).*

| | Feet. |
|---|---|
| Mean of 20 shots | 1,734 |
| Greatest velocity | 1,787 |
| Least velocity | 1,687 |

*July 20.*—Thermometer: Wet bulb, 74°; dry bulb, 79°. Barometer, 30.10 inches.

*Charge, 36 grains; third model .309 bullet (95 per cent lead and 5 per cent antimony).*

| | Feet. |
|---|---|
| Mean of 7 shots | 1,779 |
| Extreme variation | 50 |

*Same, but cartridges shaken to simulate effect of transportation.*

| | Feet. |
|---|---|
| Mean of 7 shots | 1,763 |
| Extreme variation | 142 |

*July 22.*—Thermometer: Wet bulb, 72°; dry bulb, 82°. Barometer, 30.28 inches.

The experiments with different compositions of bullet material were continued, the 97 per cent lead and 3 per cent antimony bullet being abandoned on account of the strippings previously recorded. Charge, 36 grains; third model .309 bullet used in all these experiments.

*Bullets 100 per cent lead.*

| | Feet. |
|---|---|
| Mean of 50 shots | 1,762 |
| Greatest velocity | 1,821 |
| Least velocity | 1,692 |

*Bullets 94 per cent lead and 6 per cent antimony.*

| | Feet. |
|---|---|
| Mean of 47 shots | 1,799 |
| Greatest velocity | 1,853 |
| Least velocity | 1,731 |

Three bullets stripped and missed second target.

*Accuracy at 500 yards; targets, 10 shots each; bullets 100 per cent lead.*

| Radius circle of shots. | Mean vertical deviation. |
|---|---|
| *Foot.* | *Foot.* |
| 0.88 | 0.77 |
| .57 | .42 |
| .59 | .53 |
| .57 | .34 |
| .43 | .20 |

*July 23.*

*Bullets 94 per cent lead and 6 per cent antimony.*

| Radius circle of shots. | Mean vertical deviation. | Remarks. |
|---|---|---|
| *Foot.* | *Foot.* | |
| 0.76 | 0.66 | |
| .59 | .45 | One shot missed target. |
| .60 | .48 | |
| .63 | .48 | Do. |
| .68 | .51 | |

*July 23.*—Thermometer: Wet bulb, 75°; dry bulb, 84°. Barometer 30.20 inches.

*Bullets 100 per cent lead; accuracy at 500 yards; targets, 10 shots each.*

| Radius circle of shots. | Mean vertical deviation. | Remarks. |
|---|---|---|
| *Foot.* | *Foot.* | |
| 0.66 | 0.60 | |
| .40 | .26 | Preliminary shot missed target and struck near top of screen. |
| .38 | .31 | |
| .84 | .69 | Preliminary shot did not reach target. |
| .66 | .41 | |

The two misses above recorded indicated that stripping had taken place.

*July 25.*—Thermometer: Wet bulb, 72°; dry bulb, 78°. Barometer, 29.9 inches.

*Bullets 100 per cent lead.*

| | Feet. |
|---|---|
| Mean of 10 shots | 1,777 |
| Greatest velocity | 1,826 |
| Least velocity | 1,737 |
| Mean of 10 shots | 1,768 |
| Greatest velocity | 1,810 |
| Least velocity | 1,741 |
| Mean of 10 shots | 1,752 |
| Greatest velocity | 1,800 |
| Least velocity | 1,695 |

One bullet stripped and missed second target. Total number of bullets fired, 100 per cent lead, 285. Number of bullets stripped, 3 (counting the misses in the trials for accuracy at 500 yards). Percentage of bullets stripped, 1 per cent.

In order to show the effect of turning over the copper of the jacket to cover the base of the lead core, ten bullets were prepared in which the copper was not turned over. When fired, as anticipated, all stripped.

*August 7.*—Thermometer: Wet bulb, 74°; dry bulb, 81°. Barometer, 30.08 inches. Charge, 36 grains; third model .309 bullet with cupro-nickel jacket. Penetration at 500 yards, 15 boards, 14 boards, 14 boards, 14 boards, 14 boards.

Same, except all-lead bullet with copper jacket, 16 boards, 15 boards, 14 boards, 14 boards, 14 boards.

Same, except 97 per cent lead and 3 per cent antimony, bullet with copper jacket, 15 boards, 15 boards, 14 boards, 13 boards, 13 boards.

Same, except 94 per cent lead and 6 per cent antimony, bullet with copper jacket, 15 boards, 14 boards, 14 boards, 14 boards, 13 boards.

The target used was of white pine and composed of 24 boards, each 1 inch thick, placed 1 inch apart.

*Accuracy at 500 yards; targets, 10 shots each; charge, 36 grains; third model .309 bullet, with cupro-nickel jacket.*

| Radius circle of shot. | Mean vertical deviation. |
|---|---|
| *Foot.* | *Foot.* |
| 0.55 | 0.455 |
| .49 | .355 |

*August 10.*—Thermometer: Wet bulb, 78°; dry bulb, 91°. Barometer, 29.99 inches.

*Charge, 36 grains; third model .309 bullet, cupro-nickel jacket.*

| | Feet. |
|---|---|
| Mean of 10 shots | 1,771 |
| Greatest velocity | 1,799 |
| Least velocity | 1,730 |

*August 13.*—Thermometer: Wet bulb, 67°; dry bulb, 81°. Barometer, 29.98 inches.

*Charge, 36 grains; third model .309 bullet, cupro-nickel jacket.*

| | Feet. |
|---|---|
| Mean of 10 shots | 1,797 |
| Greatest velocity | 1,825 |
| Least velocity | 1,756 |

*Same, but with aluminium-bronze jacket.*

| | Feet. |
|---|---|
| Mean of 10 shots | 1,770 |
| Greatest velocity | 1,820 |
| Least velocity | 1,684 |

The penetration of the bullets with aluminium-bronze covers was about the same as with the cupro-nickel ones.

*August 17.*—Thermometer: Wet bulb, 69°; dry bulb, 83°. Barometer, 30.07 inches.

The thickness of the copper jacket was now increased to .015 inch with the hope of entirely preventing stripping. This decreased the weight of bullet to about 226 grains.

*Charge, 36 grains; third model .309 bullet, with thick jacket (0.015 inch thick).*

| | Feet. |
|---|---|
| Mean of 99 shots | 1,773 |
| Greatest velocity | 1,864 |
| Least velocity | 1,711 |

*Accuracy at 500 yards; targets of 10 shots each.*

| Radius circle of shots. | Mean vertical deviation. |
|---|---|
| *Foot.* | *Foot.* |
| 0.45 | 0.30 |
| .49 | .40 |
| .58 | .42 |
| .61 | .47 |

*August 22.*—Thermometer: Wet bulb, 71°; dry bulb, 86°. Barometer, 29.97 inches.

*Charge, 36 grains; third model .309 bullet, with thick jacket (0.015 inch thick).*

| | Feet. |
|---|---|
| Mean of 100 shots | 1,760 |
| Greatest velocity | 1,821 |
| Least velocity | 1,711 |
| Mean of 29 shots | 1,774 |
| Greatest velocity | 1,825 |
| Least velocity | 1,714 |

One bullet stripped and missed second target.

*August 24.*—Thermometer: Wet bulb, 77°; dry bulb, 85°. Barometer, 29.95 inches.

*Accuracy at 500 yards; targets of 10 shots each.*

| Radius circle of shots. | Mean vertical deviation. | Remarks. |
|---|---|---|
| *Foot.* | *Foot.* | |
| 0.65 | 0.495 | One shot missed target. |
| .53 | .425 | |
| .63 | .405 | |
| .61 | .470 | |
| .50 | .390 | |
| .77 | .611 | Do. |
| .59 | .470 | |
| .70 | .420 | |
| .67 | .615 | |
| .37 | .340 | |

Total number of third model .309 bullets with thick jackets (0.015 inch thick) fired, 369. Number of bullets stripped, 3 (including the two misses noted above). Percentage of bullets stripped, 0.81 per cent.

## REMARKS ON THE FOREGOING EXPERIMENTS.

### CARTRIDGE CASE.

The cartridge case was found to be too weak to stand repeated reloadings, cracks and splits usually developing at the first or second reloadings. In several cases bad leaks occurred near the head, allowing large escape of gas. The thinness of neck necessary to allow the use of the .309 bullet promotes early splits and causes loss in manufacture. Difficulty of extraction was seldom experienced, and the extraction was never excessive. Owing to the fact that it was constructed to receive an unknown charge of powder and had to have a sufficient cubic capacity for any probable contingency, the cartridge case is not well adapted to the present small charge, which only partially fills it, and the bullet is hence not seated on the powder. Primer piercings and misfires were of rare occurrence.

### POWDER.

The velocities recorded in April, the month in which the powder was received, were higher than have been obtained since, using the same charges.* Experiments showed the powder to be influenced as regards velocity by exposure to moisture and by increase of temperature. The irregularity of granulation and the disposition of the charge in the cartridge case were found to have a powerful influence on the velocity, and to account for many of the apparently anomalous results recorded. Machine loading had to be abandoned, as it was found that the extreme variation in weight of charge amounted to 2 grains, corresponding to a variation of over 100 feet in velocity. Hand loading was resorted to in the preparation of the cartridges for the Magazine Gun Board, and even with this method great variations in velocity occurred. Partly consumed grains of powder were found near the muzzle of the gun after every discharge. The fouling of the gun barrel was very slight. After several hundred rounds the point of the firing pin was found to be badly eroded and had to be repaired. Pressures and velocities could not be taken at the same time during the experiments, owing to the want of a suitable rest for the pressure gauge, which has since been supplied. It was thought advisable to postpone the subject of pressures until a uniform method of testing them here and at the Springfield Armory should be decided on. Hence only the few recorded in this report were taken.

### LUBRICANT.

The experiments indicate that with the present copper jacket the amount of lubricant could be increased with advantage. A decided increase of velocity attended the use of a base lubricating disk, and "dipping" the bullets gave a similar increase.

### BULLET.

The stripping of the copper jacket from the lead core has been the principal difficulty experienced with the bullet. By increasing the amount of copper turned over at the base and by making the copper jacket thicker this stripping has been greatly lessened. In the last series of several hundred shots fired the number of strippings recorded was less than 1 per cent. Further experiments are in course of prosecution, and it is hoped in time to remedy this difficulty entirely. Cupronickel and aluminum bronze have been tried for jackets with good results as far as the limited experiments go. Jackets made of these alloys are more difficult and expensive to manufacture than when copper is used. Lead and lead combined with percentages of antimony varying from 3 to 6 per cent were tried for the bullet core in addition to the usual alloy of lead and tin. The results with pure lead were perhaps a little superior, but the trials were not at all conclusive.

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* It was found afterwards that this loss of velocity was due to the degredation of the barrel and not to a deterioration of the powder. A new rest was made for the .30-caliber pressure barrel, and velocities were taken with it which corresponded with those obtained in April and with the results noted at the Springfield Armory.

The velocities in the foregoing experiments were measured by means of two instruments on independent circuits, one a Boulengé chronograph, old model, and the other a Boulengé Bréger chronograph of American manufacture. The results obtained with these two machines showed a remarkable agreement. The accuracy was computed by the method described in Appendix 21, Report of the Chief of Ordnance, 1882.

Respectfully, your obedient servant,

J. W. BENÉT,
*First Lieut., Ord. Dept., U. S. Army.*

Approved.

GEO. W. MCKEE,
*Major, Ord. Dept., Commanding.*

# APPENDIX 17.

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## *CONSTRUCTION REPORT OF 12-INCH B. L. RIFLE, STEEL, NO. 1 TYPE—BY CAPT. LAWRENCE L. BRUFF, ORDNANCE DEPARTMENT, U. S. A.*

(Ten plates.)

This gun was manufactured at the Army gun factory, Watervliet Arsenal, N. Y.

Work on the gun was begun July 11, 1889. As the work progressed it was found that the tube and jacket had not been properly annealed abroad, and work on them was suspended January 18, 1890, and the forgings shipped to Bethlehem, Pa., for reannealing. The forgings were returned April 1, 1890, when work was resumed and the gun completed June 2, 1891. The time given includes that occupied in preparing the plant and tools as well as the actual work on the gun. Total time 1 year, 8 months, 8 days.

### FORGINGS.

The following forgings were made at Le Creusot, France:

Tube,
Jacket,
Trunnion hoop,
$A_1$ hoop.

The remaining forgings were of American steel, manufactured by the Midvale Steel Company, Philadelphia, Pa.

### DESCRIPTION OF THE GUN.

The gun is composed of—

One tube,
One jacket,
Ten C hoops,
Five D hoops,
Seven A hoops,
Eight B hoops,
One filling ring,
One copper caulking ring,
Two coupling pins,

and the various parts of the breech mechanism.

The interior tube is enveloped by the jacket and by the C hoops. The jacket projects to the rear of the tube 18.90 inches, and is in contact with the tube for a length of 154.55 inches. The C hoops extend from the front end of the jacket to the muzzle of the gun, a distance of 266.55 inches, the $C_1$ hoop being in contact with the jacket, and the hoops succeeding each other in the order of their numbers, $C_{10}$ being the muzzle hoop. Hoops $C_1$, $C_2$, $C_3$, and $C_4$ are cylindrical on the interior and of a uniform diameter; hoops $C_5$ to $C_{10}$, inclusive, are cylindrical, but of two different diameters, the interior diameters differing from each other by amounts varying from 0.70 to 0.40 inch. The diameter of the tube is uniform under the $C_1$, $C_2$, and $C_3$ hoops, but decreases at the front end of the $C_3$ hoop by 0.50 inch. It is again reduced at the front end of $C_4$ hoop the same amount, and under each of the remaining C hoops there is a reduction of diameter corresponding to the change in the enveloping hoop. The tube is thus gradually reduced in diameter from 22 inches under the jacket to 18.10 inches at the muzzle. The thickness of the tube over the powder chamber is 3.90 inches, and at the muzzle 2.55 inches.

The tube has the following shoulders under the jacket:

At rear end of tube, depth 2.50 inches.
7.80 inches from rear end, depth 0.80 inch.
At front of jacket, depth 0.25 inch.

The joints between the jacket and hoop $C_1$ $C_1$ and $C_2$ $C_2$ and $C_3$ $C_3$ and $C_4$ $C_4$ and $C_5$ are plain abutting joints. The other C hoops are locked together by lips and recesses. The tube and jacket are coupled together with two steel coupling pins, which are driven into holes drilled partly in the tube and partly in the jacket, at the front end of the latter. The pins are inserted tangentially instead of radially, as formerly in the 10-inch.

The five D hoops extend in the order of their numbers from a shoulder on the jacket towards the muzzle, overlapping the jacket and C hoops as far as the middle of $C_5$. The length of the row of D hoops is 111.50 inches. $D_1$ hoop is a locking hoop; that is, it has a recess in its interior which fits over corresponding shoulders on the front of the jacket and rear of the $C_1$ hoop. The length of this recess is, as nearly as possible, equal to the sum of the lengths of the shoulders above described, and when the hoop is shrunk on it locks together the jacket and the $C_1$ hoop. The filling ring answers the same purpose as in the 10-inch gun. $D_1$ and $D_3$ hoops are stepped; the others are cylindrical on the interior.

The A hoops extend in the order of their numbers from a shoulder beyond the middle of $D_1$ hoop to the rear of the gun, their total length being 176.20 inches. $A_1$ hoop is stepped and the others cylindrical, except $A_7$. This hoop is extra long, and is provided with an interior recess like the locking hoop $D_1$. Its object is to increase the longitudinal strength of the jacket where the pull of the breech mechanism is sustained by locking over two shoulders on the jacket. The $A_1$ hoop is stepped on the interior, and the shoulder in the hoop abuts against a corresponding shoulder on the front part of the jacket. There is also a small lip at the front of the hoop which a shoulder on the $D_1$ hoop enters. The B hoops extend in the order of their numbers from a shoulder on the exterior of the $A_1$ hoop to the rear of the gun, a distance of 153.40 inches. They are all without steps.

On the interior of the gun, at the rear, the screw thread is cut in the jacket and carries the block. A space of 0.05 inch is left between the rear end of tube and the corresponding surface of jacket, and a small conical lip on the rear end of the tube projects over this opening. A copper calking ring is inserted between the lip on the tube and the corresponding surface of the jacket.

At the rear end of the tube is the gas-check seat with its taper entrance, the total length of the two being 4.55 inches. The powder chamber is 14.20 inches in diameter and 63 inches long, breech closed, measured from front of obturator. This chamber is joined to the rifled bore by a conical slope 18 inches long. The front part of this slope forms the seat for the band of the projectile. From the front of this slope the tops of the lands of the rifling are made conical for a length of 48 inches, the diameter in rear being 12.06 inches and in front 12 inches.

The rear ends of the lands for a length of 0.981 inch have the same slope as that of the shot chamber.

### THE BREECH MECHANISM.

The breech mechanism consists of the following principal parts:

The breechblock.
The obturator.
The console or tray.
The breech plate.

#### *The breechblock.*

Attached to or forming part of it are—

The two handles.
The threaded sectors.
The slotted sectors.
The guide grooves.
The vent cover.
The vent-cover screw.
The translating stud.
The translating stud screw.
The bore for spindle and nuts of obturator.

The handles are cut as in the 10-inch gun; there are four threaded and four slotted sectors. The other parts are similar to those on the 8-inch gun, and are fully described in the report on that gun.

#### *The obturator.*

The principal parts are—

The spindle.
The front cup.
The rear cup.
The pad.
Two steel antifriction washers.
Two bronze antifriction washers.
One spring washer.
One obturator nut.
One locking nut.
The vent.
The vent bushing.
The primer seat.

These parts are similar to those of the 8-inch gun.

#### *The console or tray.*

Attached to and forming part of it are—

Two guide rails.
Recess for translating roller.
Thread in recess for roller.
Slot for translating stud.
Tray latch recess.
Hole for spring lock.
Latch bolt recess.
Hinge pin hole.

Upper washer.
Separator.
Intermediate washer. For steel balls for bearing.
Separator.
Lower washer.
Steel balls (48).
Recess for catch for securing latch.
Translating roller.
Translating crank and nut.
Tray latch.
Latch bolt.
Spring lock for latch.
Hinge pin.
Catch for securing latch.
Handle.
Slot for translating stud.

### *The breech plate.*

This is essentially the same as for the 10-inch gun. The block is rotated as in the 8-inch except that a compound gearing is used.

### *The action of the breech mechanism.*

This has already been fully described for the 8-inch gun, and is the same for the 12-inch.

#### *Principal dimensions.*

| | | |
|---|---|---|
| Diameter of bore across lands | inches | 12 |
| Number of grooves and lands each | | 72 |
| Width of lands | inches | 0.15 |
| Width of grooves | do | 0.3736 |
| Depth of grooves | do | 0.060 |
| Diameter of powder chamber | do | 14.20 |
| Length of powder chamber, breech closed | do | 66.75 |
| Volume of powder chamber | cubic inches | 12,085.90 |
| Length of rifled bore | inches | 327 |
| Thickness of tube over powder chamber | do | 3.90 |
| Thickness of jacket over powder chamber | do | 5.80 |
| Thickness of A hoops over powder chamber | do | 2.90 |
| Thickness of B hoops over powder chamber | do | 3.425 |
| Total thickness of wall over powder chamber | do | 16.025 |
| Diameter at bottom of thread in breech recess | do | 16.993 |
| Diameter at top of thread on block | do | 16.960 |
| Height of thread on block | do | 0.38 |
| Pitch of thread on block | do | 1.10 |
| Length of thread in breech recess | do | 16.50 |
| Number of threaded and slotted sectors each | | 4 |
| Exterior diameter of gun over reinforce | inches | 46.25 |
| Distance between faces of rimbases | do | 49.80 |
| Diameter of trunnions | | 14.50 |
| Total length of tube | inches | 416.30 |
| Length of jacket on tube | do | 154.55 |
| Total length of jacket | do | 173.45 |
| Total length of C hoops | do | 261.95 |
| Total length of D hoops | do | 111.50 |
| Total length of A hoops | do | 176.20 |
| Total length of B hoops | do | 153.40 |
| Length of gun, axis of trunnions to breech | do | 148 |
| Length of gun, axis of trunnions to muzzle | do | 292 |
| Total length of gun over all, breech closed | do | 440 |
| Weight of gun complete | pounds | 115,046 |
| Breech preponderance | | Zero. |

Rifling, a semicubic parabola, one turn in 50 calibers at origin; one turn in 25 calibers at 24 inches from muzzle; uniform to muzzle.

### MECHANICAL OPERATIONS BEFORE ASSEMBLING.

These have been already fully described for the 8-inch gun.

### ASSEMBLING THE PARTS.

The same methods were followed as for the 10-inch gun and the same instructions from the Chief of Ordnance governed.

#### *Shrinkages used.*

The accompanying record, "Summary of effects of shrinkage," gives a statement of the shrinkages prescribed and applied with the variations from the prescribed for the several parts or sections of the gun.

#### *Compressions due to shrinkage.*

The same record gives a comparison between the measured compressions and those anticipated as computed from the applied shrinkages for the shrinkage of each layer assembled. The comparison for total effects of shrinkage is as follows:

*Table of comparison between computed and actual compressions of bore.*

| Section of gun. | | Calculated. | Actual. | Difference. |
|---|---|---|---|---|
| | | *Inch.* | *Inch.* | *Inch.* |
| I | Breech recess | 0.0130 | 0.0125 | —0.0005 |
| II | Breech end of tube | .0166 | .0202 | + .0016 |
| III | Powder chamber | .0188 | .0224 | + .0036 |
| IV | Powder chamber to trunnion hoop | .0152 | .0182 | + .0030 |
| V | Trunnion hoop | .0153 | .0147 | — .0006 |
| VI | Shoulder of jacket | .0123 | .0137 | + .0014 |
| VII | Muzzle of jacket | .0146 | .0175 | + .0029 |
| VIII | Base of D hoops | .0143 | .0159 | + .0016 |
| VIII *sub* | Middle of D hoops | | .0152 | |
| IX | Near end of D hoops | .0128 | .0142 | + .0014 |
| IX *sub* | Ends of D hoops | | .0125 | |
| X *ante* | Base of single row of hooping | | .0093 | |
| X | Joint of hoops $C_5$ and $C_6$ | .0074 | .0078 | + .0004 |
| XI | Joint of hoops $C_6$ and $C_7$ | .0069 | .0071 | + .0002 |
| XII | Joint of hoops $C_7$ and $C_8$ | .0067 | .0069 | + .0002 |
| XIII | Joint of hoops $C_8$ and $C_9$ | .0064 | .0061 | — .0003 |
| XIV | Joint of hoops $C_9$ and $C_{10}$ | .0059 | .0063 | + .0004 |
| XV | Muzzle of gun | .0057 | .0059 | + .0002 |

### EXPANSION OF JACKET AND HOOPS BY HEAT FOR SHRINKAGE.

The details of the heating and shrinking are given in the accompanying table with the corresponding expansions and temperatures. The openings at the joints are also given in the record of shrinkage operations. These openings were measured at four points, marked 1, 2, 3, and 4, 90° apart.

The gun after being finished was shipped to the Ordnance Proving Ground at Sandy Hook, N. J.

The plates accompanying the report show the details of the construction.

The following tables and plates accompany the report:

#### TABLES.

(1) Inspection report.
(2) Record of shrinkage operations.
(3) Summary of effects of shrinkage.

### PLATES.

(I) Elevation and section of gun.
(II) Details of hoops and joints.
(III) Details of hoops, joints, and chamber.
(IV) Details of hoops, joints, and rifling.
(V) Details of breech mechanism; breech locked, ready for firing.
(VI) Details of breech mechanism; movements of block and tray
(VII) Details of breech mechanism; obturator, etc.
(VIII) Details of breech mechanism; face plate and rotating gear.
(IX) Details of breech mechanism; tray and rollers.
(X) Shrinkages, curves of resistances, and compressions.

(4826–'91.)

### *Report of inspection of 12-inch B. L. rifle (steel), No. 1, manufactured at the Watervliet Arsenal, under orders of the Chief of Ordnance, U. S. Army, dated July 3, 1889.*

[Dimensions given in inches, unless otherwise expressed. Where no sign is prefixed to the figures given in the column of allowed variations the double sign, plus or minus, will be understood.]

| Subject of measurement. | Dimensions. | | Variations. | |
|---|---|---|---|---|
| | Prescribed. | Actual. | Allowed. | Actual. |
| Total length of gun over all, breech closed | 440.000 | 440.000 | 0.10 | 0 |
| Length— | | | | |
| From muzzle to first step | 161.000 | 160.960 | 0.05 | -0.040 |
| From muzzle to second step | 259.000 | 258.950 | 0.05 | -0.050 |
| From muzzle to front of trunnion hoop | 281.500 | 281.480 | 0.05 | -0.020 |
| From muzzle to axis of trunnions | 292.000 | 291.960 | -0.05 | -0.040 |
| From breech to axis of trunnions | 148.000 | 148.000 | +0.05 | 0 |
| Of trunnion hoop | 21.000 | 20.796 | 0.01 | -0.026 |
| Of trunnions, right | 8.500 | 8.501 | 0.01 | +0.001 |
| Of trunnions, left | 8.500 | 8.500 | 0.01 | 0 |
| Of rimbases | 1.000 | 1.000 | 0.02 | 0 |
| Of tube, total | 416.300 | 416.293 | 0.05 | -0.007 |
| Of true bore, cylindrical | 279.000 | 279.000 | 0.05 | 0 |
| Of conical bore | 48.000 | 48.000 | 0.05 | 0 |
| Of rifling | 327.000 | 327.000 | 0.05 | 0 |
| Of chamber slope | 18.000 | 18.000 | 0.025 | 0 |
| Of powder chamber, cylindrical | 66.750 | 66.750 | 0.02 | 0 |
| Of gas-check seat | 3.750 | 3.750 | 0.02 | 0 |
| Of bore from front of spindle, breech closed | 408.000 | 407.999 | 0.05 | -0.001 |
| Of breech recess | 18.900 | 18.900 | 0.01 | 0 |
| Of thread in breech recess | 16.500 | 16.500 | 0.02 | 0 |
| Of spindle, total | 28.250 | 28.250 | 0.02 | 0 |
| Between front faces of spindle and breech-block | 7.250 | 7.250 | 0.02 | 0 |
| Of breechblock, handles excluded | 24.750 | 24.751 | 0.01 | +0.001 |
| Of thread on block, top line | 17.650 | 17.650 | 0.02 | 0 |
| Of jacket, total | 173.450 | 173.450 | 0.03 | 0 |
| Of C hoops, total | 261.750 | 261.678 | 0.03 | -0.072 |
| Of D hoops, total | 111.500 | 111.435 | 0.03 | -0.065 |
| Of A hoops, total | 176.200 | 176.194 | 0.03 | -0.006 |
| Of B hoops, total | 153.400 | 153.394 | 0.03 | -0.006 |
| Distance between rimbases, out to out | 49.800 | 49.829 | 0.04 | +0.029 |
| Diameter— | | | | |
| Of true bore, across lands | 12.000 | 12.000<br>12.001 | +0.003 | +0.001 |
| Of conical bore, rear | 12.060 | 12.060 | +0.003 | 0 |
| Of gas-check seat, rear | 14.500 | 14.493 | (*) | -0.0070 |
| Of breech recess in slots | 17.020 | 17.0175 | +0.005 | -0.0025 |
| Of breech recess at bottom of threads | 16.995 | 16.993 | 0.002 | -0.002 |
| Of breech recess at top of threads | 16.245 | 16.243 | 0.002 | -0.002 |
| Of breechblock in slots | 16.170 | 16.162 | -0.005 | -0.008 |
| Of breechblock at bottom of threads | 16.210 | 16.202 | 0.002 | -0.008 |
| Of breechblock at top of threads | 16.960 | 16.960 | 0.002 | 0 |
| Of head of spindle, maximum | 14.150 | 14.148 | 0.005 | -0.002 |
| Of stem of spindle | 4.960<br>3.950 | 4.960<br>3.950 | 0.002 | 0<br>0 |
| Of powder chamber | 14.200 | 14.2035 | 0.003 | +0.0035 |
| Of vent in spindle | 0.200 | 0.200 | 0.002 | 0 |
| Of vent in copper bushing | 0.100 | 0.100 | 0.002 | 0 |
| Pitch of thread in breech | 1.100 | 1.100 | .......... | 0 |
| Number— | | | | |
| Of sectors in breech | 4 | 4 | .......... | 0 |
| Of rifling grooves and lands, each | 72 | 72 | .......... | 0 |
| Width— | | | | |
| Of grooves | 0.3736 | 0.3736 | 0.002 | 0 |
| Of lands | 0.150 | 0.150 | 0.002 | 0 |
| Depth of grooves | 0.060 | 0.0595 | +0.003 | +0.0005 |
| Twist of rifling— | | | | |
| At origin, one turn in calibers † | 50 | 50 | .......... | 0 |
| At 24 inches from muzzle, calibers ‡ | 25 | 25 | .......... | 0 |
| Diameters on exterior of tube: § | | | | |
| Breech to first shoulder | 17.000 | 17.000 | 0.01 | 0 |
| First to second shoulder | 20.400 | 20.400 | 0.01 | 0 |
| Second to third shoulder | 22.000 | 21.9955 | 0.01 | -0.0045 |
| Third to fourth shoulder | 22.500 | 22.496 | 0.01 | -0.004 |
| Fourth to fifth shoulder | 21.500 | 21.500 | 0.01 | 0 |
| Fifth to sixth shoulder | 21.000 | 20.9995 | 0.01 | -0.0005 |
| Sixth to seventh shoulder | 20.400 | 20.39975 | 0.01 | -0.00025 |
| Seventh to eighth shoulder | 19.800 | 19.7995 | 0.01 | -0.0005 |

* To fit gauge.

† Increasing.

‡ Uniform to muzzle.

§ The measurements entered here are the interior diameters of jacket, etc., which differ from the exterior of tube by the amount of shrinkage.

*Report of inspection of 12-inch B. L. rifle (steel), No. 1, etc.*—Continued.

| Subject of measurement. | Dimensions. | | Variations. | |
|---|---|---|---|---|
| | Prescribed. | Actual. | Allowed. | Actual. |
| Diameters on exterior of tube—Continued. | | | | |
| Eighth to ninth shoulder | 19.200 | 19.201 | 0.01 | +0.001 |
| Ninth to tenth shoulder | 18.500 | 18.5005 | .......... | +0.0005 |
| Tenth to eleventh shoulder | 17.800 | 17.7995 | .......... | —0.0005 |
| Eleventh to twelfth shoulder | 17.400 | 17.402 | .......... | +0.003 |
| Twelfth to thirteenth shoulder | 17.100 | 17.100 | .......... | 0 |
| Diameters on exterior of jacket: * | | | | |
| Breech to first shoulder | 32.800 | 32.8015 | 0.01 | +0.0015 |
| First to second shoulder | 33.600 | 33.60175 | 0.01 | +0.00175 |
| Second to third shoulder (locking recess) | 33.540 | 33.540 | 0.01 | 0 |
| Third to fourth shoulder | 33.600 | 33.599 | 0.01 | —0.001 |
| Fourth to fifth shoulder | 35.100 | 35.10025 | 0.01 | +0.00025 |
| Fifth to sixth shoulder (locking recess) | 28.500 | 28.49975 | 0.01 | —0.00025 |
| Sixth shoulder to muzzle end | 28.600 | 28.59975 | 0.01 | —0.00025 |
| Diameter on exterior of A hoops † | 39.400 | 39.39925 | 0.01 | —0.00075 |
| Diameters on exterior of C hoops: ‡ | | | | |
| Muzzle of jacket to first shoulder | 28.600 | 28.5995 | 0.01 | —0.0005 |
| First to second shoulder | 27.600 | 27.6005 | 0.01 | +0.0005 |
| Second to third shoulder, and to end of D row | 26.400 | 26.3995 | 0.01 | —0.0005 |
| Diameter— | | | | |
| Of trunnion hoop, exterior | 47.800 | 47.829 | .......... | +0.029 |
| Of trunnions, right | 14.500 | 14.500 | 0.01 | 0 |
| Of trunnions, left | 14.500 | 14.499 | 0.005 | —0.001 |
| Of gun over reinforce, exterior | 46.250 | 46.243 | 0.005 | —0.007 |
| Of gun in front of trunnion hoop | 43.600 | 43.598 | 0.01 | —0.002 |
| Of gun in front of A hoops | 36.500 | 36.493 | 0.01 | —0.007 |
| Of gun in front of D hoops | 26.400 | 26.403 | 0.01 | +0.003 |
| Of gun at muzzle, off round | 20.500 | 20.536 | 0.01 | +0.036 |
| Axis of trunnions above (below) axis of gun | 0 | 0 | 0.01 | 0 |
| Weights— | *Pounds.* | *Pounds.* | *Pounds.* | *Pounds.* |
| Of translating roller and crank | .......... | 82 | .......... | .......... |
| Of breech block | .......... | 1,135 | .......... | .......... |
| Of console | .......... | 367½ | .......... | .......... |
| Of hinge pin | .......... | 24½ | .......... | .......... |
| Of spindle | .......... | 228 | .......... | .......... |
| Of gas-check cups and pad | .......... | 71 | .......... | .......... |
| Of washers and nuts | .......... | 17 | .......... | .......... |
| Of gun without fermeture | .......... | 113,153 | .......... | .......... |
| Total weight of gun | 116,480 | 115,046 | .......... | —1,434 |
| Preponderance at face of breech, gun complete | 0 | 0 | .......... | 0 |
| Weight of revolving crank and securing latch | .......... | 18 | .......... | .......... |

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* Interior diameters of A hoops, etc.

† Interior diameter of B hoops, etc.

‡ Interior diameters of D hoops, etc.

Marks on finished gun: 12-inch No. 1; weight, 51¼ tons 115.046 pounds. L. L. B., inspector. Watervleit Arsenal, 1891.

Material (designated by the marks of the inspectors of material): Steel forgings manufactured by Midvale Steel Company, except where marks are inclosed in parentheses, which were manufactured by Schneider & Co., Le Creusot, France. Tube (12 R, 1 T); jacket (12 R, 1 J). Hoops: A$_1$ (12 R, 1 A$_1$); A$_2$ (TH), 12 R 1; A$_3$, 12 R, 1 A$_3$; A$_4$, 12 R$_1$ A$_4$; A$_5$, 12 R$_1$ A$_5$; B$_1$ (TH) (12 R$_1$ TH); B$_2$, 12 R$_1$ B$_2$; B$_3$, 12 R$_1$ B$_3$; B$_4$, 12 R$_1$ B$_4$; B$_5$, 12 R B$_5$; C$_1$, 12 R$_1$ C$_1$; C$_2$, 12 R$_1$ C$_2$; C$_3$, 12 R$_1$ C$_3$; C$_4$, 12 R$_1$ C$_4$; C$_5$, 12 R$_1$ C$_5$; C$_6$, 12 R$_1$ C$_6$; C$_7$, 12 R$_1$ C$_7$; D$_1$, 12 R$_1$ D$_1$; D$_2$, 12 R$_1$ D$_2$; D$_3$, 12 R$_1$ D$_3$. Breech parts: BU 12 R$_1$ BU; BP (cast), 12 R$_1$ BP; BB, 12 R$_1$ BB; SP, 12 R$_1$ SP; GC, 12 R$_1$ GC; HP, 12 R$_1$ HP; RR, 12 R$_1$ RR; TrR, 12 R$_1$ TrR; Pn, 12 R Pn.

I certify that the foregoing report is correct, and that the 12-inch rifle therein specified has been accepted by me as conforming to the standards as to dimensions, quality of material, and character or workmanship prescribed by the Ordnance Department.

Date of inspection May 26, 27, and 28, 1891.

LAWRENCE L. BRUFF,
*Captain, Ord. Dept., U. S. Army, Inspector.*

*Record of inspection of 12-inch B. L. steel rifle, type No. 1, manufactured at Watervliet Arsenal, West Troy, N. Y., under orders of the Chief of Ordnance, U. S. Army, dated July 3, 1889.*

RECORD OF SHRINKAGE OPERATIONS.

| Jacket and hoops. | Intervals of time. | | | | | Expansion and temperature of metal. | | | | | | Openings at joints in cooling. | | | | | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Prescribed expansions. | | | Final expansions. | | | | | | | | |
| | In furnace heating. | Furnace to position. | Position to pressure applied. | Furnace to water on. | Water applied. | Gauge-rod set. | Expansion. | Clearance. | Absolute. | Relative. | Highest temperature. | 1 | 2 | 3 | 4 | Average. | |
| | *h. m.* | *h. m.* | *h. m.* | *h. m.* | *h. m.* | *Inches.* | *Inch.* | *Inch.* | *Inch.* | *Per in.* | °*F.** | *Inch.* | *Inch.* | *Inch.* | *Inch.* | *Inch.* | |
| Jacket..... | 19 27 | 0 19¾ | 0 0 | 0 23 | 10 50 | 22.100 | 0.104 | 0.09075 | 0.104 | 0.0047 | 671 | 0.007 | 0.005 | 0.004 | 0.009 | 0.006 | |
| Hoop A¹... | 4 9 | 0 9¾ | 0 2 | 0 12¾ | 1 39 | 33.730 | 0.13025 | 0.0805 | 0.13025 | 0.0038 | 543 | 0.008 | 0.008 | 0.009 | 0.009 | 0.0085 | Doors of furnace open 2 hours, to arrange shrinking apparatus. |
| Hoop A²... | 2 30 | 0 6¼ | 0 1 | 0 8 | 1 37 | 33.730 | 0.12925 | 0.0795 | 0.12925 | 0.0038 | 543 | 0.010 | 0.010 | 0.012 | 0.007 | 0.009 | Doors of furnace open 1 hour, to arrange shrinkage apparatus. |
| Hoop A³... | 1 45 | 0 4 | 0 0½ | 0 5 | 1 10 | 33.730 | 0.12975 | 0.08025 | 0.12975 | 0.0038 | 543 | 0.007 | 0.006 | 0.010 | 0.007 | 0.0075 | |
| Hoop A⁴... | 2 5 | 0 6 | 0 0½ | 0 7 | 1 3 | 33.730 | 0.132 | 0.083 | 0.132 | 0.0039 | 557 | 0.013 | 0.010 | 0.008 | 0.009 | 0.010 | |
| Hoop A⁵... | 1 38 | 0 5 | 0 1 | 0 6 | 1 11 | 33.730 | 0.1315 | 0.0825 | 0.1315 | 0.0039 | 557 | 0.008 | 0.009 | 0.009 | 0.008 | 0.0085 | |
| Hoop A⁶... | 2 19 | 0 5 | 1 | 0 7 | 1 34 | 33.730 | 0.1305 | 0.080 | 0.1305 | 0.0035 | 500 | 0.010 | 0.010 | 0.014 | 0.011 | 0.011 | Doors of furnace open ½ hour, to arrange shrinking apparatus. |
| Hoop A⁷... | 7 31 | 0 7 | 0 1 | 0 9 | 1 20 | 32.979 | 0.17725 | 0.0585 | 0.17725 | 0.0052 | 743 | 0.015 | 0.015 | 0.016 | 0.018 | 0.016 | |
| Hoop B¹... | 4 48 | 0 6 | 0 1 | 0 8 | 2 4 | 39.534 | 0.13425 | 0.091 | 0.13425 | 0.0034 | 485 | 0.008 | 0.008 | 0.009 | 0.009 | 0.0085 | |
| Hoop B²... | 3 47 | 0 6 | 0 3 | 0 10 | 1 18 | 39.534 | 0.134 | 0.085 | 0.134 | 0.0034 | 485 | 0.008 | 0.005 | 0.010 | 0.009 | 0.008 | Doors of furnace open 1 hour, to arrange shrinking apparatus. |
| Hoop B³... | 2 4 | 0 5 | 0 3 | 0 9 | 1 2 | 39.534 | 0.1355 | 0.087 | 0.1355 | 0.0034 | 485 | 0.008 | 0.008 | 0.008 | 0.010 | 0.0085 | Doors of furnace open 1 hour, to arrange shrinking apparatus. |
| Hoop B⁴... | 2 3 | 0 5 | 0 0½ | 0 6 | 0 46 | 39.534 | 0.13475 | 0.0855 | 0.13475 | 0.0034 | 485 | 0.012 | 0.008 | 0.007 | 0.008 | 0.008 | Doors of furnace partly open ½ hour, to arrange shrinking apparatus. |
| Hoop B⁵... | 2 12 | 0 5 | 0 1 | 0 6 | 1 7 | 39.534 | 0.1345 | 0.085 | 0.1345 | 0.0034 | 485 | 0.008 | 0.008 | 0.009 | 0.010 | 0.0085 | Doors open and hoop out of furnace 20 minutes, to readjust lifting strap. |
| Hoop B⁶... | 1 15 | 0 5 | 0 0½ | 0 5½ | 0 45 | 39.534 | 0.133 | 0.087 | 0.133 | 0.0033 | 471 | 0.007 | 0.008 | 0.008 | 0.009 | 0.008 | |
| Hoop B⁷... | 1 15 | 0 5 | 0 1 | 0 6 | 0 40 | 39.534 | 0.13425 | 0.0855 | 0.13425 | 0.0034 | 485 | 0.004 | 0.006 | 0.008 | 0.005 | 0.006 | |
| Hoop B⁸... | 1 43 | 0 7 | 0 1 | 0 8 | 0 45 | 39.534 | 0.13425 | 0.0855 | 0.13425 | 0.0034 | 485 | 0.017 | 0.012 | 0.012 | 0.015 | 0.014 | |
| Hoop C¹.... | 2 36 | 0 5 | 0 0½ | 0 6 | 1 3 | 21.587 | 0.08675 | 0.054 | 0.08675 | 0.004 | 571 | 0.003 | 0.004 | 0.003 | 0.003 | 0.003 | |
| Hoop C².... | 5 49 | 0 5 | 0 1 | 0 6 | 1 0 | 21.587 | 0.08725 | 0.0555 | 0.08725 | 0.004 | 571 | 0.003 | 0.005 | 0.003 | 0.003 | 0.0035 | |
| Hoop C³.... | 4 21 | 0 5 | 0 1 | 0 6 | 1 24 | 21.587 | 0.087 | 0.0555 | 0.087 | 0.004 | 571 | 0.003 | 0.004 | 0.003 | 0.003 | 0.003 | Doors of furnace open part of time, to arrange apparatus. |
| Hoop C⁴.... | 4 1 | 0 5 | 0 0½ | 0 6 | 0 44 | 21.083 | 0.08275 | 0.0525 | 0.08275 | 0.0039 | 557 | 0.004 | 0.005 | 0.002 | 0.003 | 0.0035 | Doors of furnace open 1½ hours, to face off hoop C³. |
| Hoop C⁵.... | 3 10 | 0 4 | 0 1 | 0 5 | 1 26 | 20.481 | 0.08025 | 0.050 | 0.08025 | 0.0039 | 557 | 0.003 | 0.005 | 0.004 | 0.004 | 0.004 | |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hoop C⁶.... | 2 48 | 0 5 | 0 0½ | 0 6 | 1 6 | 19.880 | 0.07850 | 0.0645 | 0.07850 | 0.0089 | 557 | 0.004 | 0.004 | 0.003 | 0.004 | 0.004 | |
| Hoop C⁷.... | 2 81 | 0 3 | 0 0½ | 0 4 | 0 55 | 19.277 | 0.07425 | 0.0525 | 0.07425 | 0.004 | 571 | 0.007 | 0.006 | 0.005 | 0.007 | 0.006 | |
| Hoop C⁸.... | 2 27 | 0 5 | 0 0½ | 0 6 | 0 50 | 18.575 | 0.07325 | 0.053 | 0.07325 | 0.0039 | 557 | 0.005 | 0.003 | 0.005 | 0.002 | 0.004 | |
| Hoop C⁹.... | 1 12 | 0 6 | 0 0½ | 0 8 | 1 0 | 17.870 | 0.0695 | 0.0515 | 0.0695 | 0.0039 | 557 | 0.003 | 0.005 | 0.005 | 0.005 | 0.0045 | |
| Hoop C¹⁰... | 1 21 | 0 4 | 0 0½ | 0 5 | 1 54 | 17.489 | 0.086 | 0.068 | 0.086 | 0.0049 | 700 | 0.003 | 0.005 | 0.006 | 0.005 | 0.004 | |
| Hoop D¹ ... | 2 44 | 0 8 | 0 1 | 0 11 | 0 35 | 28.671 | 0.171 | 0.08975 | 0.171 | 0.0059 | 843 | 0.039 | 0.040 | 0.033 | 0.033 | 0.036 | |
| Hoop D² ... | 3 0 | 0 5 | 0 0½ | 0 6 | 1 9 | 27.710 | 0.1075 | 0.077 | 0.1075 | 0.0089 | 557 | 0.010 | 0.009 | 0.014 | 0.015 | 0.012 | Doors open and hoop out of furnace 1 hour, to readjust lifting strap. |
| Hoop D³ ... | 1 28 | 0 6 | 0 0½ | 0 7 | 1 30 | 26.512 | 0.11125 | 0.08075 | 0.11125 | 0.0042 | 600 | 0.008 | 0.006 | 0.007 | 0.008 | 0.007 | |
| Hoop D⁴ ... | 1 20 | 0 4 | 0 0½ | 0 5 | 1 3 | 26.512 | 0.112 | 0.083 | 0.112 | 0.0042 | 600 | 0.009 | 0.006 | 0.007 | 0.008 | 0.0075 | |
| Hoop D⁵ ... | 1 59 | 0 5 | 0 0½ | 0 6 | 1 0 | 26.510 | 0.11125 | 0.081 | 0.11125 | 0.0042 | 600 | 0.015 | 0.019 | 0.016 | 0.015 | 0.016 | |

* To be estimated. Divide the expansion per inch by 0.000007.

LAWRENCE L. BRUFF,
*Captain, Ord. Dept., U. S. Army, Inspector.*

*Summary of effects of shrinkage of 12-inch B. L. rifle (steel), No. 1,*

| | Sections of gun. | | Diameters of jacket or hoops. | | | Shrinkages. | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Designation. | Limits, distance from breech. | Exterior. | | Interior. | Order of. | Prescribed. | | |
| | | | Actual. | Prescribed. | Prescribed. | | Relative. | Absolute. | Allowed variation. |
| | | *Inches.* (1) | *Inches.* (2) | *Inches.* (3) | *Inches.* (*a*) | (5) | *Thousandths.* (*b*) | *Inch.* *a* × *b* | *Inch.* (8) |
| I. | Breech recess | 0–19.7 | 39.52 | 39.40 | 32.8<br>33.6 | 2d | 1.4691 | 0.0480<br>0.0494 | +0.002<br>—0.001 |
| | | | 46.88 | 46.25 | 39.4 | 3d | 1.0224 | 0.0403 | +0.001<br>—0.002 |
| II. | Breech end of tube | 19.7 –26.7 | 34.26 | 33.6 | 20.4 | 1st | 0.6645 | 0.0136 | +0.002<br>—0.001 |
| | | | 39.52 | 39.4 | 33.6 | 2d | 1.4691 | 0.0494 | +0.002<br>—0.001 |
| | | | 46.37 | 46.25 | 39.4 | 3d | 1.2259 | 0.0483 | +0.001<br>—0.002 |
| III. | Powder chamber | 26.7 –98.2 | 34.26 | 33.6 | 22.0 | 1st | 0.7344 | 0.0162 | +0.002<br>—0.001 |
| | | | 39.57 | 39.4 | 33.6 | 2d | 1.4691 | 0.0494 | +0.002<br>—0.001 |
| | | | 46.38 | 46.25 | 39.4 | 3d | 1.2259 | 0.0483 | +0.001<br>—0.002 |
| IV. | Powder chamber to trunnion hoop. | 98.2 –132.7 | 34.25 | 33.6 | 22.0 | 1st | 0.7344 | 0.0162 | +0.002<br>—0.001 |
| | | | 39.53 | 39.4 | 33.6 | 2d | 1.4691 | 0.0494 | +0.002<br>—0.001 |
| | | | 46.38 | 46.25 | 46.25 | 3d | 1.2259 | 0.0483 | +0.001<br>—0.002 |
| V. | Trunnion hoop | 132.7 –153.7 | 34.25 | 33.6 | 22.0 | 1st | 0.7344 | 0.0162 | +0.002<br>—0.001 |
| | | | 39.51 | 39.4 | 33.6 | 2d | 1.4691 | 0.0494 | +0.002<br>—0.001 |
| | | | 47.78 | 47.8 | 39.4 | 3d | 1.0565 | 0.0416 | +0.001<br>—0.002 |
| VI. | Shoulder of jacket | 153.7 –162.7 | ........ | 35.1 | 22.0 | 1st | 0.7344 | 0.0162 | +0.002<br>—0.001 |
| | | | | 43.6 | 35.1 | 2d | 1.4294 | 0.0502 | +0.001<br>—0.002 |
| VII. | Muzzle of jacket | 162.7 –175.7 | 28.71 | 28.5 | 22.0 | 1st | 0.7344 | 0.0162 | +0.002<br>—0.001 |
| | | | 35.2 | 35.1 | 28.5 | 2d | 1.0707 | 0.0305 | +0.001<br>—0.002 |
| | | | | 42.0 | 35.1 | 3d | 1.3574 | 0.0476 | +0.001<br>—0.002 |

*at Army Gun Factory, Watervliet Arsenal, June 5, 1891.*

| Shrinkages, actual (measured). | | | Diameters of bore. | | | Compression of bore. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Before shrinkage. | | After shrinkage. | Actual. | | Computed. | | | |
| Absolute. | Per cent of prescribed. | Variation. | Prescribed. | Actual. | Actual. | Measured. | Relative. | From prescribed shrinkages. | From actual shrinkages. | Variation from actual. | Estimated, including initial tension for cast-iron steel-hooped mortars. |
| *Inch.* $e$ | *P. ct.* $\frac{e}{a.b}$ | *Inch.* $e-a.b$ | *Inches.* (12) | *Inches.* $d$ | *Inches.* | *Inch.* $e$ | *Thousandths.* $\frac{e}{d}$ | *Inch.* $f$ | *Inch.* $f\frac{c}{a.b}$ | *Inch.* $e-f\frac{c}{a.b}$ | *Pounds per square in.* $\left(\text{Modulus.}\right)\times\frac{e}{d}+$ I. T.* |
| 0.0482<br>0.0486 | 98.4 | —0.0008 | 17.0 | 16.2100 | 16.2016 | 0.0084 | ........ | 0.0080 | 0.0079 | +0.0005 | |
| 0.0389 | 96.2 | —0.0015 | ...... | ....... | 16.1975 | 41 | ........ | 53 | 51 | —0.0010 | |
| | | | | | | 0.0125 | 0.771 | 0.0133 | 0.0130 | —0.0005 | 23,100 |
| 0.0135 | 99.2 | —0.0001 | 14.2 | 14.0979 | 14.0899 | 0.0080 | ........ | 0.0072 | 0.0071 | +0.0009 | |
| 0.0486 | 98.4 | —0.0008 | ...... | ....... | 14.0815 | 84 | ........ | 65 | 64 | +0.0020 | |
| 0.0471 | 97.5 | —0.0012 | ...... | ....... | 14.0777 | 38 | ........ | 52 | 51 | —0.0013 | |
| | | | | | | 0.0202 | 1.433 | 0.0189 | 0.0186 | +0.0016 | 43,000 |
| 0.0161 | 99.4 | —0.0001 | 14.2 | 14.0982 | 14.0879 | 0.0103 | ........ | 0.0072 | 0.0072 | +0.0031 | |
| 0.0494 | 100.0 | 0.0000 | ...... | ....... | 14.0795 | 84 | ........ | 65 | 65 | +0.0019 | |
| 0.0473 | 98.0 | —0.0010 | ...... | ....... | 14.0758 | 37 | ........ | 52 | 51 | —0.0014 | |
| | | | | | | 0.0224 | 1.589 | 0.0189 | 0.0188 | +0.0036 | 47,700 |
| 0.0161 | 99.4 | —0.0001 | 12.06 | 11.748 | 11.7397 | 0.0083 | ........ | 0.0057 | 0.0057 | +0.0026 | |
| 0.0495 | 100.5 | +0.0001 | ...... | ....... | 11.7342 | 55 | ........ | 52 | 52 | +0.0003 | |
| 0.0489 | 101.4 | +0.0006 | ...... | ....... | 11.7298 | 44 | ........ | 42 | 43 | +0.0001 | |
| | | | | | | 0.0182 | 1.550 | 0.0151 | 0.0152 | +0.0030 | 46,500 |
| 0.0164 | 101.5 | +0.0002 | 12.02 | 11.748 | 11.7428 | 0.0052 | ........ | 0.0057 | 0.0057 | —0.0005 | |
| 0.0496 | 100.7 | +0.0002 | ...... | ....... | 11.7368 | 60 | ........ | 52 | 52 | +0.0008 | |
| 0.0435 | 102.2 | +0.0009 | ...... | ....... | 11.7333 | 35 | ........ | 42 | 44 | —0.0009 | |
| | | | | | | 0.0147 | 1.261 | 0.0151 | 0.0153 | —0.0006 | 37,500 |
| 0.0165 | 101.8 | +0.0003 | 12.0 | 11.748 | 11.7428 | 0.0052 | ........ | 0.0059 | 0.0060 | —0.0008 | |
| 0.0493 | 98.2 | —0.0009 | ...... | ....... | 11.7343 | 85 | ........ | 64 | 63 | +0.0022 | |
| | | | | | | 0.0137 | 1.166 | 0.0123 | 0.0123 | —0.0014 | 35,000 |
| 0.0164 | 101.5 | +0.0002 | 12.0 | 11.748 | 11.7434 | 0.0046 | ........ | 0.0042 | 0.0043 | +0.0003 | |
| 0.0311 | 102.0 | +0.0006 | ...... | ....... | 11.7367 | 67 | ........ | 49 | 50 | +0.0017 | |
| 0.0487 | 102.3 | +0.0011 | ...... | ....... | 11.7305 | 62 | ........ | 52 | 53 | +0.0009 | |
| | | | | | | 0.0175 | 1.490 | 0.0143 | 0.0146 | +0.0029 | 44,700 |

*Initial tension zero. Modulus = 30,000,000 pounds.

*Summary of effects of shrinkage of 12-inch B. L. rifle (steel), No 1,*

| | Sections of gun. | | Diameters of jacket or hoops. | | | Shrinkages. | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Designation. | Limits, distance from breech. | Exterior. | | Interior. | Order of. | Prescribed. | | |
| | | | Actual. | Prescribed. | Prescribed. | | Relative. | Absolute. | Allowed variation. |
| | | *Inches.* (1) | *Inches.* (2) | *Inches.* (3) | *Inches.* (*a*) | (5) | *Thousandths.* (*b*) | *Inch.* *a* × *b* | *Inch.* (8) |
| VIII. | Base of D-hoops........ | 175.7 -214.0 | 27.71 | 27.6 | 21.5 | 1st. | 1.4175 | 0.0306 | +0.002<br>−0.001 |
| | | | 35.2 | 35.1 | 27.6 | 2d.. | 1.2011 | 0.0330 | +0.001<br>−0.002 |
| VIII*sub*. | Middle of D-hoops .... | 214.0 -241.2 | 26.53 | 26.4 | 21.5 | 1st. | 1.4175 | 0.0305 | +0.002<br>−0.001 |
| | | | 33.35 | 33.255 | 26.4 | 2d.. | 1.2011 | 0.0317 | +0.001<br>−0.002 |
| IX. | End of D-hoops........ | 241.2 -263.2 | 26.51 | 26.4 | 21.0 | 1st. | 1.3471 | 0.0283 | +0.002<br>−0.001 |
| | | | 32.0 | 31.9 | 20.4 | 2d.. | 1.1397 | 0.0300 | +0.001<br>−0.002 |
| IX *sub*. | Extreme end of D-hoops | 263.2 -274.2 | 26.51 | 26.4 | 20.4 | 1st. | 1.0971 | 0.0224 | +0.001<br>−0.002 |
| | | | tapered | tapered | 26.4 | 2d.. | 1.1397 | 0.0300 | +0.001<br>−0.002 |
| X *ante*. | Base of single row of hooping. | 274.2 -282.45 | tapered | tapered | 20.4 | 1st. | 1.0971 | 0.0224 | +0.003 |
| X. | Joint of hoops $C_5$ and $C_6$. | 282.45-313.45 | 26.26 | 25.689 | 19.8 | 1st. | 1.0971 | 0.0217 | +0.003 |
| XI. | Joint of hoops $C_6$ and $C_7$. | 313.45-342.45 | 24.65 | 24.536 | 19.2 | 1st. | 1.0202 | 0.0196 | +0.003 |
| XII. | Joint of hoops $C_7$ and $C_8$. | 342.45-371.45 | 23.55 | 23.464 | 18.5 | 1st. | 0.9650 | 0.0178 | +0.003 |
| XIII. | Joint of hoops $C_8$ and $C_9$. | 371.45-399.45 | 22.45 | 22.363 | 17.8 | 1st. | 0.9363 | 0.0167 | +0.003 |
| XIV. | Joint of hoops $C_9$ and $C_{10}$. | 399.45-421.45 | 21.53 | 21.427 | 17.4 | 1st. | 0.8962 | 0.0156 | +0.003 |
| XV. | Muzzle of gun......... | 421.45-435.2 | 20.7 | 20.6 | 17.1 | 1st. | 0.8621 | 0.0147 | +0.003 |

The diameter 32″.8 extends for 7″.0 inches from breech of jacket.

### NOTES IN REGARD TO MEAN VALUES OF ACTUAL SHRINKAGES AND COMPRESSIONS OF BORE.

Columns *c* and *e*, taken from Form 40 E.

#### SHRINKAGES.

SECTION II.—Third shrinkage, omit 3″.0 for conical surface.

SECTION IV.—Third shrinkage, omit 2″.0 for conical surface.

SECTION VII.—First shrinkage, omit 3″.0 (171–173) on shoulder of tube where $D_1 = 22.5$ instead of 22.0, for which length prescribed $S_1 = 0''.0165$ and actual $S_1 = 0''.018$. Second shrinkage, include 2″.0 (176–177) of section VIII over the diameter 28″.6. Third shrinkage, omit 4″.0 (173–176) reduced shrinkage.

SECTION IX *sub*.—Second shrinkage, omit cone 5″.0 (269–273) at end of D row.

SECTIONS VIII *sub*., IX *sub*., and X *ante*.—There are no computations for the particular diameters occurring in these lengths. The second shrinkage (relative) of section VIII extends over VIII *sub*. The second shrinkage (relative) of IX extends over IX *sub*., and the shrinkage (relative) of X extends back to X *ante*. They are placed separately in the summary to show actual measurements only.

SECTION XIV.—The conical shrinkage surface (423–435) is included, assuming the average values for the remainder of the section.

*at Army Gun Factory, Watervliet Arsenal, June 5, 1891*—Continued.

| Shrinkages, actual (measured). | | | Diameters of bore. | | | Compression of bore. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Before shrinkage. | | After shrinkage. | Actual. | | Computed. | | Variation from actual. | Estimated, including initial tension for cast-iron-steel-hooped mortars. |
| Absolute. | Per cent of prescribed. | Variation. | Prescribed. | Actual. | Actual. | Measured. | Relative. | From prescribed shrinkages. | From actual shrinkages. | | |
| *Inch.* (c) | *P. ct.* $\frac{c}{a.b}$ | *Inch.* $c-a.b$ | *Inches.* (12) | *Inches.* $d$ | *Inches.* | *Inch.* $e$ | *Thousandths.* $\frac{e}{d}$ | *Inch.* $f$ | *Inch.* $f\frac{c}{a.b}$ | *Inch.* $e-f\frac{c}{a.b}$ | *Pounds per square in.* $\left(\text{Modulus} \times \frac{e}{d}\right) + \text{I. T.*}$ |
| 0.0319 | 104.6 | +0.0014 | 12.0 | 11.748 | 11.7390 | 0.0090 | ........ | 0.0081 | 0.0085 | +0.0005 | |
| 0.0315 | 95.4 | —0.0015 | ...... | ....... | 11.7321 | 69 | ........ | 61 | 58 | +0.0011 | |
| | | | | | | 0.0159 | 1.354 | 0.0142 | 0.0143 | +0.0016 | 40,600 |
| 0.0322 | ...... | +0.0017 | 12.0 | 11.748 | 11.7396 | 0.0084 | ........ | ...... | ...... | ........ | |
| 0.0305 | ...... | —0.0012 | ...... | ....... | 11.7328 | 68 | ........ | ...... | ...... | ........ | |
| | | | | | | 0.0152 | 1.294 | ...... | ...... | ........ | 38,800 |
| 0.0307 | 108.5 | +0.0024 | 12.0 | 11.7481 | 11.7398 | 0.0083 | ........ | 0.0073 | 0.0079 | +0.0004 | |
| 0.0302 | 100.7 | +0.0002 | ...... | ....... | 11.7339 | 59 | ........ | 49 | 49 | +0.0010 | |
| | | | | | | 0.0142 | 1.209 | 0.0122 | 0.0128 | +0.0014 | 36,300 |
| 0.0343 | ...... | +0.0019 | 12.0 | 11.7485 | 11.7413 | 0.0072 | ........ | ...... | ...... | ........ | |
| 0.0306 | ...... | +0.0006 | ...... | ....... | 11.7360 | 53 | ........ | ...... | ...... | ........ | |
| | | | | | | 0.0125 | 1.064 | ...... | ...... | ........ | 31,900 |
| 0.0346 | ...... | +0.0022 | 12.0 | 11.7485 | 11.7392 | 0.0093 | 0.791 | ...... | ...... | ........ | 23,700 |
| 0.0239 | 110.2 | +0.0022 | 12.0 | 11.7486 | 11.7408 | 0.0078 | 0.664 | 0.0067 | 0.0074 | +0.0004 | 19,930 |
| 0.0221 | 112.8 | +0.0025 | 12.0 | 11.7488 | 11.7417 | 0.0071 | 0.604 | 0.0061 | 0.0069 | +0.0002 | 18,120 |
| 0.0208 | 116.8 | +0.0030 | 12.0 | 11.7490 | 11.7421 | 0.0069 | 0.586 | 0.0058 | 0.0067 | +0.0002 | 17,580 |
| 0.0187 | 111.9 | +0.0020 | 12.0 | 11.7497 | 11.7436 | 0.0061 | 0.518 | 0.0057 | 0.0064 | —0.0003 | 15,540 |
| 0.0179 | 114.2 | +0.0022 | 12.0 | 11.7500 | 11.7437 | 0.0063 | 0.535 | 0.0052 | 0.0059 | +0.0004 | 16.050 |
| 0.0175 | 119.1 | +0.0028 | 12.0 | 11.7503 | 11.7444 | 0.0059 | 0.501 | 0.0048 | 0.0057 | +0.0002 | 15,030 |

* Initial tension zero. Modulus = 30,000,000 pounds.

COMPRESSIONS OF BORE.

SECTIONS III and IV.—Omit the length, 91-108, over front slope of powder chamber not measured for compression.

SECTION VI.—The increase of compression due to assemblage of trunnion hoop which extends over this section is added to the compression under second shrinkage.

SECTION VII.—Omit 4″.0 (173-176) under third shrinkage (hoop $H_1$), because of the arbitrary reduction of shrinkage made in that length.

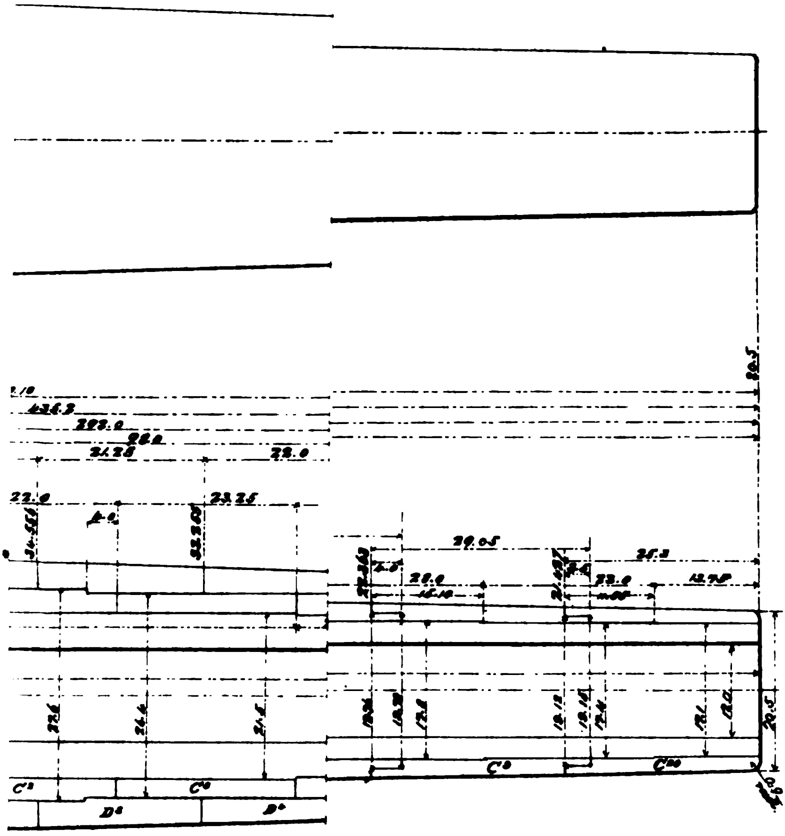
SECTION VIII.—The increase of compression as noted for section VI is added to that under third shrinkage

SECTION'S X *ante* and X.—The increase of compression due to assemblage of $D_2$ which extends over this section is added to the compression under shrinkage of C hoops.

LAWRENCE L. BRUFF,
*Captain, Ord. Dept., U. S. Army, Inspector.*

# IFLE.— STEEL,

## TYPE.



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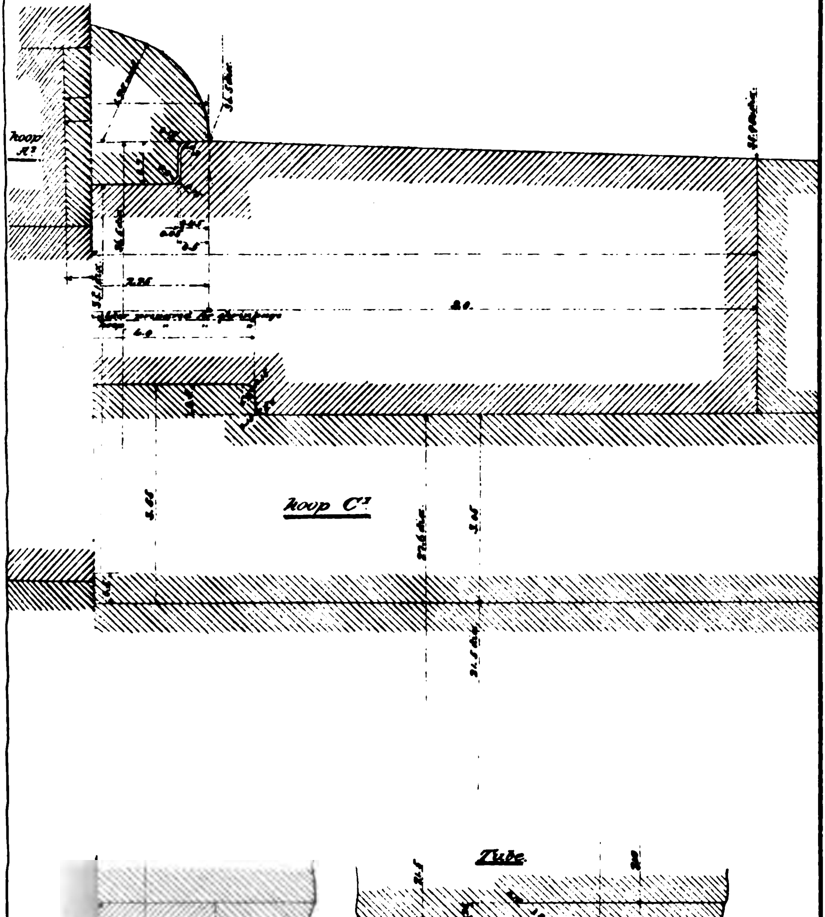
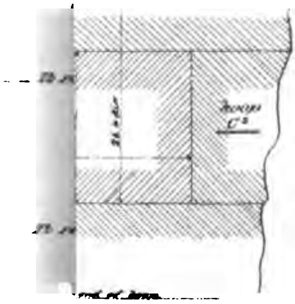
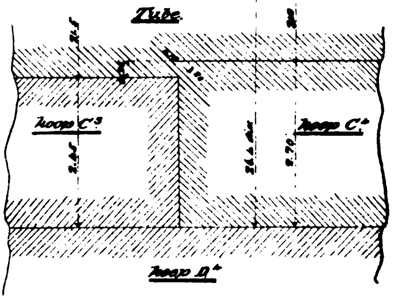
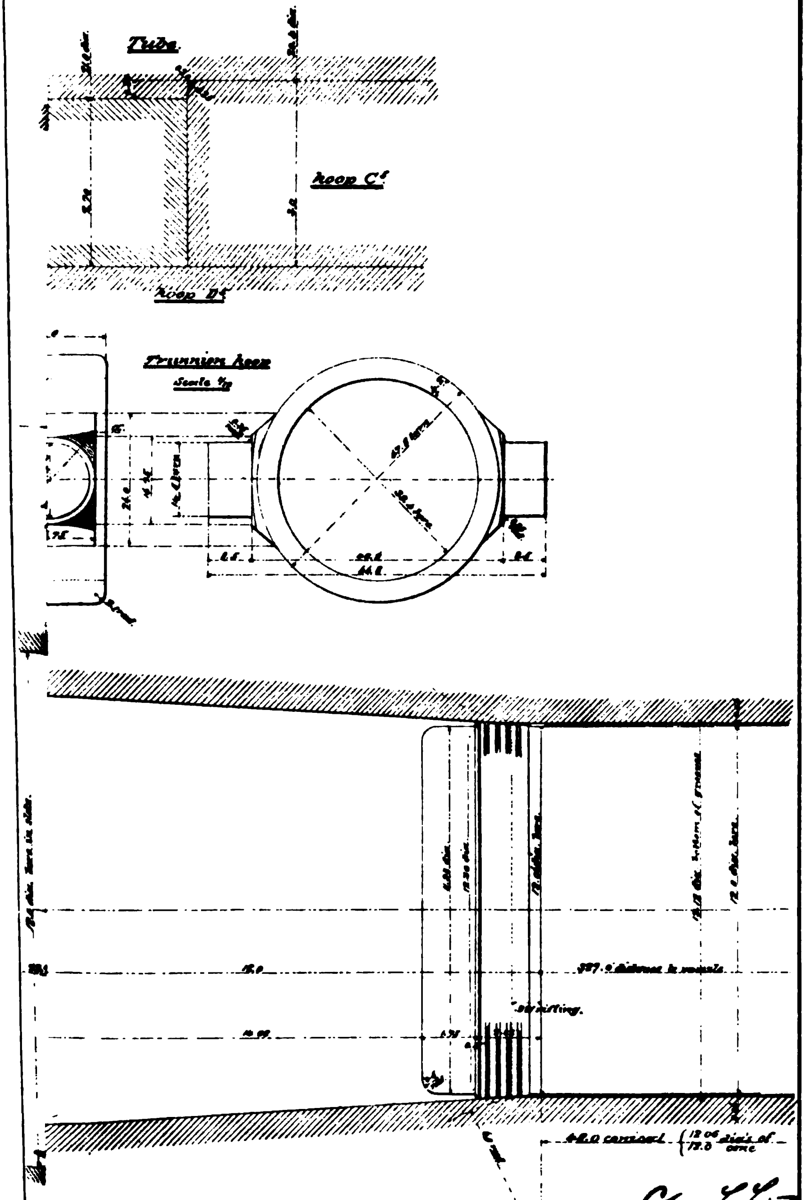
*Captain Ordnance Dept.,*
*Principal Assistant.*





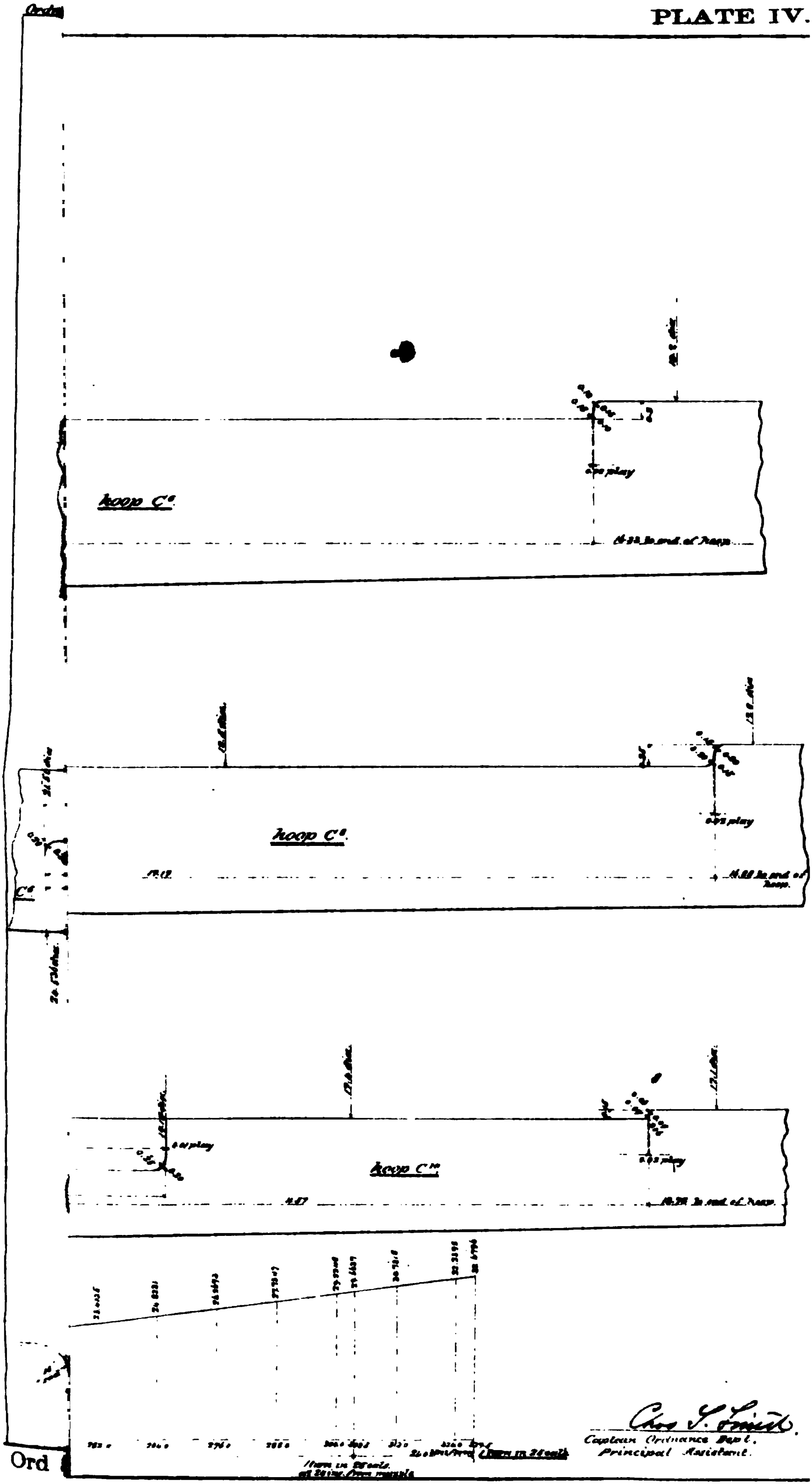


Chas. S. Smith,
Captain Ordnance Dep't.,
Principal Assistant.



Chas. S. Smith

Captain Ordnance Dept.,
Principal Assistant.



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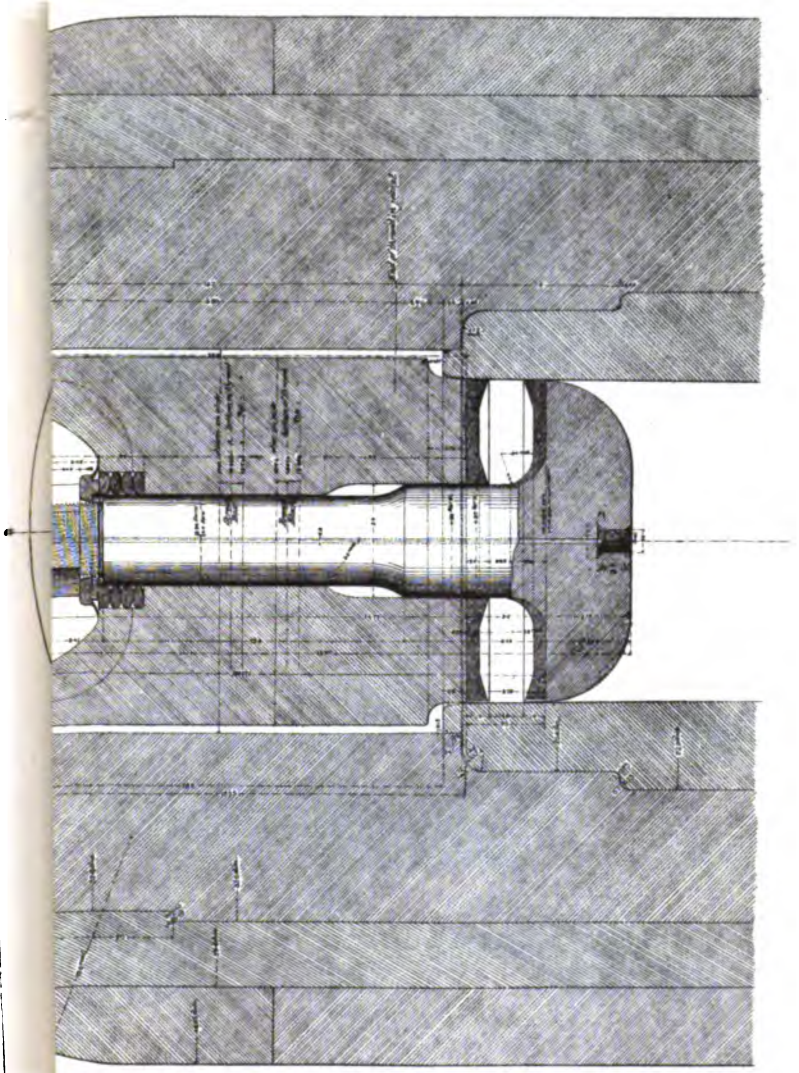
Principal Assistant.



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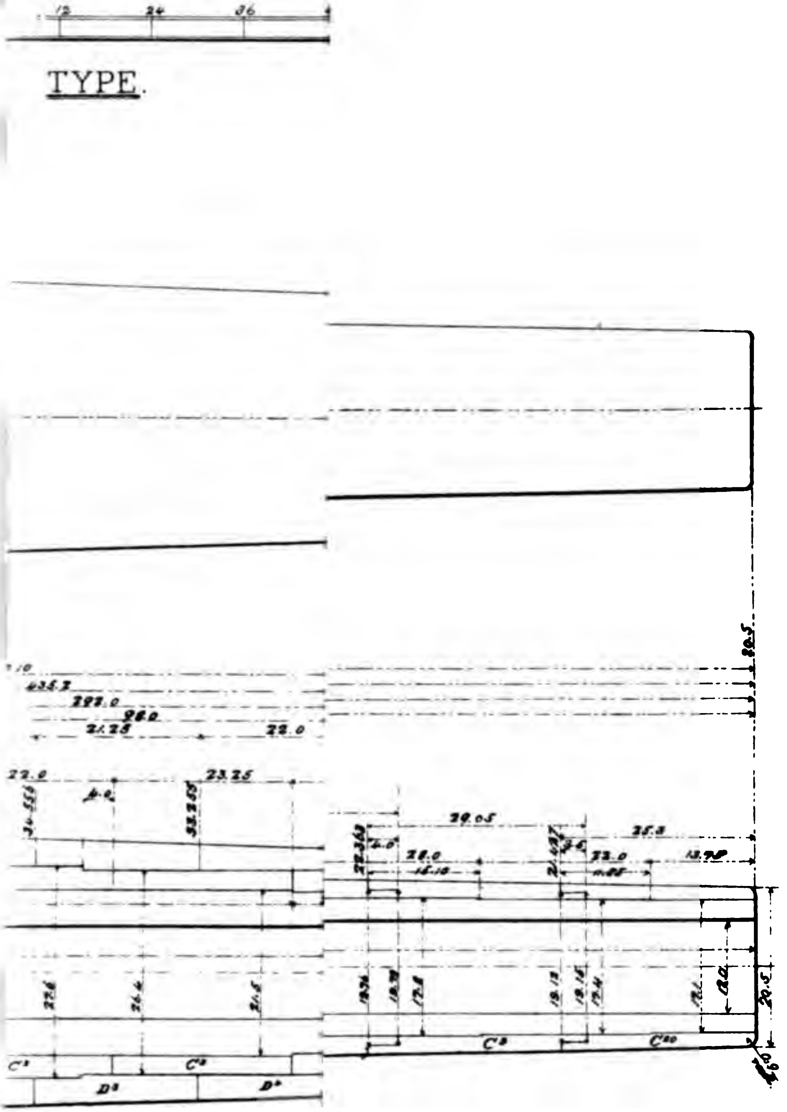
# FLE.— STEEL,

TYPE.



Chas S. Smith.

Captain Ordnance Dept.,
Principal Assistant.

# APPENDIX 18.

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## *CONSTRUCTION REPORT OF 12-INCH B. L. MORTAR, STEEL, NO. 1 TYPE; BY CAPT. LAWRENCE L. BRUFF, ORDNANCE DEPARTMENT, U. S. A.*

(Seven plates.)

This mortar was manufactured at the Army Gun Factory, Watervliet Arsenal, N. Y.

Work on the mortar was begun September 23, 1890, and it was completed June 25, 1891. Total time, 10 months 2 days.

### FORGINGS.

These were all of American steel.

### DESCRIPTION OF THE MORTAR.

The mortar is composed of—

One tube,
One jacket,
Two C hoops,
One D hoop,
Three A hoops,
One base ring,
One copper packing ring, and the various parts of the breech mechanism.

The interior tube is enveloped by the jacket and the C hoops. The tube is inserted into the jacket from the rear, as in the 8-inch guns, and abuts against a shoulder on the forward part of the jacket. There is a corresponding shoulder on the tube. These shoulders prevent any forward movement of the tube. The base ring is screwed into the rear end of the jacket, and carries at its front end a copper packing ring, which is compressed against the rear tube by screwing in the base ring under heavy pressure. This arrangement prevents any rear motion of the tube. The base ring is held in place and rotation prevented by three coupling pins, which are halved into the jacket and base ring. The base ring carries on its interior surface the slotted screw thread for the breechblock.

The C hoops extend from the front end of the jacket to the muzzle of the tube, a distance of 71 inches, $C_1$ hoop being in contact with the jacket. Both the C hoops are stepped, the diameters of $C_1$ being 19.50 and 18.80 inches, and of $C_2$, 18.80 and 18 inches. The diameter of the tube is thus reduced gradually from 20 inches under the jacket to 18 inches at the muzzle. The thickness of the tube over the powder chamber is 3.75 inches and at the muzzle 3 inches.

The tube has the following shoulders:

Under the jacket, depth 0.25 inch.
Under $C_1$ hoop, depth 0.35 inch.
Under $C_2$ hoop, depth 0.40 inch.

All the joints between hoops are plain abutting joints.

The $D_1$ hoop rests against a shoulder on the exterior front end of the jacket, and envelops part of the front end of jacket and the rear end of $C_1$ hoop. Its length is 18 inches. Its interior is cylindrical.

The A hoops extend in the order of their numbers, from a shoulder at the rear end of $D_1$ hoop to the rear of the mortar, a distance of 68.50 inches. $A_1$ hoop is the front hoop, and the hoops are all cylindrical on the interior. $A_1$ hoop envelops the rear of $D_1$ and the jacket; the others envelop the jacket.

On the interior of the mortar at the rear the screw thread is cut in the jacket for the base ring, as previously explained.

At the rear end of the tube is the gas-check seat, its total length being 2.875 inches. The powder chamber is 12.50 inches in diameter and 20.20 inches long, measured from the front of the obturator, breech closed. This chamber is joined to the rifle bore by a conical slope 4.20 inches long. The front part of this slope forms the seat for the band of the projectile. From the front of this slope the tops of the lands of the rifling are made conical for a length of 30 inches, the diameter at the rear being 12.07 inches and in front 12 inches.

### THE BREECH MECHANISM.

The breech mechanism is composed of the following principal parts:

The breech block.
The obturator.
The face plate or banjo.
The tray.
The hinge block.
The rack.
The catch.

### THE BREECHBLOCK.

Attached to and forming part of it are—

The threaded sectors (3).
The slotted sectors (3).
The guide grooves.
The bore for spindle and nuts of obturator.
The slot for face plate or banjo.
The holes for screw bolts for banjo.

### THE OBTURATOR.

The principal parts are—

The spindle.
The front cup.
The rear cup.
The pad.
Two steel antifriction washers.
Two bronze antifriction washers.
One spring washer.
One obturator nut.
One locking nut.
The vent.
The vent bushing.
The primer seat.

### THE FACE PLATE OR BANJO.

This plate is attached to the rear face of the breechblock by five screw bolts and a transverse dovetailed slot, and it carries many of the working parts of the breech mechanism. In its general shape it is a circular disk of steel, having the same exterior diameter as that of the breechblock. One diameter, however, is prolonged in a vertical direction, giving a radial arm which carries the mechanism for rotating the block, and which gives to the plate the general shape of a banjo, whence the name.

The central portion of the banjo is bored out to the same taper and size as the opening in the breech-block for the reception of the spindle and nuts of the obturator, and forms a continuous opening with that of the breech-block. The accompanying plates show the details.

Attached to and forming part of the banjo are—

The central opening.
The radial arm.
The holes for screw bolts.
The guide grooves.
The slot for translating stud.
The translating stud.
The handle.
The slot for vent-closer.
The vent-closer.
The bushings for upper and lower gear journals.
The lock for rotating crank.
The hole for journal of rotating crank.
The hole for rotating-gear journal.
The mortise for rotating gears.
The rotating gears (3).
The rotating crank.
The nut for rotating crank.

The rotating device works as follows (see plate):

On the upper journal in the mortise at the end of the radial arm of the banjo there are two gears, one of them, the larger, inside the mortise, the smaller outside and at the front. On a journal directly below this is a third pinion in gear with the larger one above it. On the rear end of this lower journal is the rotating crank. When the breech is closed the upper small gear enters a rack upon the rear outer face of the breech and the teeth become engaged. A rotation of the crank causes the motion to be transmitted through its gearing to the rack and pinion and moves the radial arm of the banjo, and with it the breechblock to the right or left, as the case may be.

The vent-closer works in a slot in the banjo, and its upper end has a projecting stud which moves in a groove cut in the rear face of the breech of the mortar. This groove is concentric with the bore till near the end of the rotation of the block in closing, when it becomes eccentric and causes the vent-closer to rise and uncover the vent. It is made in two parts, connected by a screw, so that it can be readily removed.

The lock for the rotating crank is intended to hold the crank in its proper position when the breech is closed, and to prevent any rotation of the block in firing. It consists of—

The housing.
The nut.
The stud.
The spring.

Its action will be seen by examining the detailed drawing.

### THE TRAY.

Attached to or forming part of it are—

Two guide rails.
Recess for translating roller.
Thread in recess for roller.
Slot for translating stud.
Cap for front end of recess of translating roller.
Tray-latch recess.
Hole for spring lock.
Latch-bolt recess.
Hinge-pin hole.
Catch for securing latch.
Translating roller.
Translating crank and nut.
Tray latch.
Latch bolt.
Spring lock for latch.
Hinge pin.
Handle.

The translating crank differs from that in use on the 8, 10, and 12 inch guns in having a spring joint by which the handle can be turned up against the crank, and thus allow the increased elevation required without striking the carriage.

### THE HINGE BLOCK.

As there is no breech plate in the mortar the tray is carried by a hinge block which is let into the rear face of the breech and secured by dovetails and by four screw bolts. The recess for the side latch is made in the hinge block, and the side latch is held by a pivot passing through the hinge block.

### THE RACK.

This is of steel, and is let into the outer rear face of the mortar, a groove being cut out for it. The teeth of the rack are on the interior, and hence a cut is made below it in the breech to allow the gear of the banjo to enter. (See plate.)

### THE CATCH.

This is screwed into the rear face of the breech and held in addition by two screw bolts. The tray latch engages in it when the tray is swung around to close the breech, and it thus acts as the catch does in the 8, 10, and 12 inch guns.

### THE ACTION OF THE BREECH MECHANISM.

This has already been fully explained for the 8-inch gun, and is exactly the same for the mortar, except that the block is rotated by means of the rack on the mortar, and the gears on the banjo, instead of by the gear ring and gearing, as in the 8-inch gun.

#### PRINCIPAL DIMENSIONS.

| | | |
|---|---|---|
| Diameter of bore across lands | inches | 12 |
| Number of grooves and lands, each | do | 72 |
| Width of lands | do | .15 |
| Width of grooves | do | .3736 |
| Depth of grooves | do | .070 |
| Diameter of powder chamber | do | 12.50 |
| Length of powder chamber, breech closed | do | 20.20 |

| | | |
|---|---|---|
| Volume of powder chamber | cubic inches.. | 2,636.20 |
| Length of rifled bore | inches.. | 95.10 |
| Thickness of tube over powder chamber | do.... | 3.75 |
| Thickness of jacket over powder chamber | do.... | 5.25 |
| Thickness of A hoops over powder chamber | do.... | 3.75 |
| Total thickness of wall over powder chamber | do.... | 12.75 |
| Diameter at bottom of thread in breech recess | do.... | 14.50 |
| Diameter at top of thread on block | do.... | 14.465 |
| Height of thread on block | do.... | .320 |
| Pitch of thread on block | do.... | .960 |
| Length of thread in breech recess | do.... | 13.60 |
| Number of threaded and slotted sectors, each | | 3 |
| Exterior diameter of gun over reinforce | inches.. | 38 |
| Distance between faces of rimbases | do.... | 39.98 |
| Diameter of trunnions | do.... | 12 |
| Total length of tube | do.... | 125.625 |
| Length of jacket on tube | do.... | 54.625 |
| Total length of jacket | do.... | 70.125 |
| Total length of C hoops | do.... | 71 |
| Total length of D hoop | do.... | 18 |
| Total length of A hoops | do.... | 68.50 |
| Length of mortar, axis of trunnion to breech | do.... | 51.00 |
| Length of mortar, axis of trunnion to muzzle | do.... | 90.125 |
| Total length of gun over all, breech closed | do.... | 141.125 |
| Weight of gun, complete | pounds.. | 28,971 |
| Breech preponderance | do.... | 63 |

Rifling a semicubic parabola, one turn in 40 calibers at origin, one turn in 20 calibers at 17.10 inches from muzzle-uniform to muzzle.

### MECHANICAL OPERATIONS BEFORE ASSEMBLING.

Same as for 8-inch gun.

### ASSEMBLING THE PARTS.

Same as for 8-inch gun.

### SHRINKAGES USED.

The accompanying record, "Summary of effects of shrinkage," gives a statement of the shrinkages prescribed and applied, with the variations from the prescribed, for the several sections of the mortar.

### COMPRESSIONS DUE TO SHRINKAGE.

The same record gives a comparison between the measured compressions and those anticipated, as computed from the *applied* shrinkages, for the shrinkage of each layer assembled. The comparison for total effects of shrinkage is as follows:

*Table of comparison between anticipated and actual compressions of bore.*

| | Section of mortar. | Calculated compression. | Actual compression. | Difference. |
|---|---|---|---|---|
| | | *Inches.* | *Inches.* | *Inches.* |
| I | Breech recess | 0.0106 | 0.0082 | —0.0024 |
| II | Powder chamber | 0.0158 | 0.0150 | —0.0008 |
| III<br>III | Trunnion hoop | 0.0153 | 0.0174 | +0.0021 |
| sub. | | ............ | 0.0184 | ............ |
| IV | Shoulder of jacket | 0.0142 | 0.0181 | +0.0039 |
| V | To end of A row | 0.0151 | 0.0161 | +0.0010 |
| VI | To end of D row | 0.0122 | 0.0127 | +0.0005 |
| VII | To second shoulder on tube | 0.0076 | 0.0085 | +0.0009 |
| VIII | Joint $C_1$ and $C_2$ | 0.0062 | 0.0071 | +0.0009 |
| IX | Near muzzle of mortar | 0.0055 | 0.0054 | —0.0001 |

# Appendix 18.

## *CONSTRUCTION REPORT OF 12-INCH B. L. MORTAR, STEEL, NO. 1 TYPE; BY CAPT. LAWRENCE L. BRUFF, ORDNANCE DEPARTMENT, U. S. A.*

(Seven plates.)

This mortar was manufactured at the Army Gun Factory, Watervliet Arsenal, N. Y.

Work on the mortar was begun September 23, 1890, and it was completed June 25, 1891. Total time, 10 months 2 days.

### FORGINGS.

These were all of American steel.

### DESCRIPTION OF THE MORTAR.

The mortar is composed of—

One tube,
One jacket,
Two C hoops,
One D hoop,
Three A hoops,
One base ring,
One copper packing ring, and the various parts of the breech mechanism.

The interior tube is enveloped by the jacket and the C hoops. The tube is inserted into the jacket from the rear, as in the 8-inch guns, and abuts against a shoulder on the forward part of the jacket. There is a corresponding shoulder on the tube. These shoulders prevent any forward movement of the tube. The base ring is screwed into the rear end of the jacket, and carries at its front end a copper packing ring, which is compressed against the rear tube by screwing in the base ring under heavy pressure. This arrangement prevents any rear motion of the tube. The base ring is held in place and rotation prevented by three coupling pins, which are halved into the jacket and base ring. The base ring carries on its interior surface the slotted screw thread for the breechblock.

The C hoops extend from the front end of the jacket to the muzzle of the tube, a distance of 71 inches, $C_1$ hoop being in contact with the jacket. Both the C hoops are stepped, the diameters of $C_1$ being 19.50 and 18.80 inches, and of $C_2$, 18.80 and 18 inches. The diameter of the tube is thus reduced gradually from 20 inches under the jacket to 18 inches at the muzzle. The thickness of the tube over the powder chamber is 3.75 inches and at the muzzle 3 inches.

The tube has the following shoulders:

Under the jacket, depth 0.25 inch.
Under $C_1$ hoop, depth 0.35 inch.
Under $C_2$ hoop, depth 0.40 inch.

All the joints between hoops are plain abutting joints.

The $D_1$ hoop rests against a shoulder on the exterior front end of the jacket, and envelops part of the front end of jacket and the rear end of $C_1$ hoop. Its length is 18 inches. Its interior is cylindrical.

The A hoops extend in the order of their numbers, from a shoulder at the rear end of $D_1$ hoop to the rear of the mortar, a distance of 68.50 inches. $A_1$ hoop is the front hoop, and the hoops are all cylindrical on the interior. $A_1$ hoop envelops the rear of $D_1$ and the jacket; the others envelop the jacket.

On the interior of the mortar at the rear the screw thread is cut in the jacket for the base ring, as previously explained.

At the rear end of the tube is the gas-check seat, its total length being 2.875 inches. The powder chamber is 12.50 inches in diameter and 20.20 inches long, measured from the front of the obturator, breech closed. This chamber is joined to the rifle bore by a conical slope 4.20 inches long. The front part of this slope forms the seat for the band of the projectile. From the front of this slope the tops of the lands of the rifling are made conical for a length of 30 inches, the diameter at the rear being 12.07 inches and in front 12 inches.

### THE BREECH MECHANISM.

The breech mechanism is composed of the following principal parts:

The breech block.
The obturator.
The face plate or banjo.
The tray.
The hinge block.
The rack.
The catch.

### THE BREECHBLOCK.

Attached to and forming part of it are—

The threaded sectors (3).
The slotted sectors (3).
The guide grooves.
The bore for spindle and nuts of obturator.
The slot for face plate or banjo.
The holes for screw bolts for banjo.

### THE OBTURATOR.

The principal parts are—

The spindle.
The front cup.
The rear cup.
The pad.
Two steel antifriction washers.
Two bronze antifriction washers.
One spring washer.
One obturator nut.
One locking nut.
The vent.
The vent bushing.
The primer seat.

### THE FACE PLATE OR BANJO.

This plate is attached to the rear face of the breechblock by five screw bolts and a transverse dovetailed slot, and it carries many of the working parts of the breech mechanism. In its general shape it is a circular disk of steel, having the same exterior diameter as that of the breechblock. One diameter, however, is prolonged in a vertical direction, giving a radial arm which carries the mechanism for rotating the block, and which gives to the plate the general shape of a banjo, whence the name.

The central portion of the banjo is bored out to the same taper and size as the opening in the breech-block for the reception of the spindle and nuts of the obturator, and forms a continuous opening with that of the breech-block. The accompanying plates show the details.

Attached to and forming part of the banjo are—

The central opening.
The radial arm.
The holes for screw bolts.
The guide grooves.
The slot for translating stud.
The translating stud.
The handle.
The slot for vent-closer.
The vent-closer.
The bushings for upper and lower gear journals.
The lock for rotating crank.
The hole for journal of rotating crank.
The hole for rotating-gear journal.
The mortise for rotating gears.
The rotating gears (3).
The rotating crank.
The nut for rotating crank.

The rotating device works as follows (see plate):

On the upper journal in the mortise at the end of the radial arm of the banjo there are two gears, one of them, the larger, inside the mortise, the smaller outside and at the front. On a journal directly below this is a third pinion in gear with the larger one above it. On the rear end of this lower journal is the rotating crank. When the breech is closed the upper small gear enters a rack upon the rear outer face of the breech and the teeth become engaged. A rotation of the crank causes the motion to be transmitted through its gearing to the rack and pinion and moves the radial arm of the banjo, and with it the breechblock to the right or left, as the case may be.

The vent-closer works in a slot in the banjo, and its upper end has a projecting stud which moves in a groove cut in the rear face of the breech of the mortar. This groove is concentric with the bore till near the end of the rotation of the block in closing, when it becomes eccentric and causes the vent-closer to rise and uncover the vent. It is made in two parts, connected by a screw, so that it can be readily removed.

The lock for the rotating crank is intended to hold the crank in its proper position when the breech is closed, and to prevent any rotation of the block in firing. It consists of—

The housing.
The nut.
The stud.
The spring.

Its action will be seen by examining the detailed drawing.

### THE TRAY.

Attached to or forming part of it are—

Two guide rails.
Recess for translating roller.
Thread in recess for roller.
Slot for translating stud.
Cap for front end of recess of translating roller.
Tray-latch recess.
Hole for spring lock.
Latch-bolt recess.
Hinge-pin hole.
Catch for securing latch.
Translating roller.
Translating crank and nut.
Tray latch.
Latch bolt.
Spring lock for latch.
Hinge pin.
Handle.

The translating crank differs from that in use on the 8, 10, and 12 inch guns in having a spring joint by which the handle can be turned up against the crank, and thus allow the increased elevation required without striking the carriage.

### THE HINGE BLOCK.

As there is no breech plate in the mortar the tray is carried by a hinge block which is let into the rear face of the breech and secured by dovetails and by four screw bolts. The recess for the side latch is made in the hinge block, and the side latch is held by a pivot passing through the hinge block.

### THE RACK.

This is of steel, and is let into the outer rear face of the mortar, a groove being cut out for it. The teeth of the rack are on the interior, and hence a cut is made below it in the breech to allow the gear of the banjo to enter. (See plate.)

### THE CATCH.

This is screwed into the rear face of the breech and held in addition by two screw bolts. The tray latch engages in it when the tray is swung around to close the breech, and it thus acts as the catch does in the 8, 10, and 12 inch guns.

### THE ACTION OF THE BREECH MECHANISM.

This has already been fully explained for the 8-inch gun, and is exactly the same for the mortar, except that the block is rotated by means of the rack on the mortar, and the gears on the banjo, instead of by the gear ring and gearing, as in the 8-inch gun.

#### PRINCIPAL DIMENSIONS.

| | | |
|---|---|---|
| Diameter of bore across lands | inches | 12 |
| Number of grooves and lands, each | do | 72 |
| Width of lands | do | .15 |
| Width of grooves | do | .3736 |
| Depth of grooves | do | .070 |
| Diameter of powder chamber | do | 12.50 |
| Length of powder chamber, breech closed | do | 20.20 |

| | | |
|---|---|---|
| **Volume of powder chamber** | cubic inches.. | 2,636.20 |
| **Length of rifled bore** | inches.. | 95.10 |
| **Thickness of tube over powder chamber** | do.... | 3.75 |
| **Thickness of jacket over powder chamber** | do.... | 5.25 |
| **Thickness of A hoops over powder chamber** | do.... | 3.75 |
| **Total thickness of wall over powder chamber** | do.... | 12.75 |
| **Diameter at bottom of thread in breech recess** | do.... | 14.50 |
| **Diameter at top of thread on block** | do.... | 14.465 |
| **Height of thread on block** | do.... | .320 |
| **Pitch of thread on block** | do.... | .960 |
| **Length of thread in breech recess** | do.... | 13.60 |
| **Number of threaded and slotted sectors, each** | | 3 |
| **Exterior diameter of gun over reinforce** | inches.. | 38 |
| **Distance between faces of rimbases** | do.... | 39.98 |
| **Diameter of trunnions** | do.... | 12 |
| **Total length of tube** | do.... | 125.625 |
| **Length of jacket on tube** | do.... | 54.625 |
| **Total length of jacket** | do.... | 70.125 |
| **Total length of C hoops** | do.... | 71 |
| **Total length of D hoop** | do.... | 18 |
| **Total length of A hoops** | do.... | 68.50 |
| **Length of mortar, axis of trunnion to breech** | do.... | 51.00 |
| **Length of mortar, axis of trunnion to muzzle** | do.... | 90.125 |
| **Total length of gun over all, breech closed** | do.... | 141.125 |
| **Weight of gun, complete** | pounds.. | 28,971 |
| **Breech preponderance** | do.... | 63 |

**Rifling a semicubic parabola, one turn in 40 calibers at origin, one turn in 20 calibers at 17.10 inches from muzzle-uniform to muzzle.**

### MECHANICAL OPERATIONS BEFORE ASSEMBLING.

**Same as for 8-inch gun.**

### ASSEMBLING THE PARTS.

**Same as for 8-inch gun.**

### SHRINKAGES USED.

**The accompanying record, "Summary of effects of shrinkage," gives a statement of the shrinkages prescribed and applied, with the variations from the prescribed, for the several sections of the mortar.**

### COMPRESSIONS DUE TO SHRINKAGE.

**The same record gives a comparison between the measured compressions and those anticipated, as computed from the *applied* shrinkages, for the shrinkage of each layer assembled. The comparison for total effects of shrinkage is as follows:**

*Table of comparison between anticipated and actual compressions of bore.*

| | Section of mortar. | Calculated compression. | Actual compression. | Difference. |
|---|---|---|---|---|
| | | *Inches.* | *Inches.* | *Inches.* |
| I | Breech recess | 0.0106 | 0.0082 | —0.0024 |
| II | Powder chamber | 0.0158 | 0.0150 | —0.0008 |
| III | Trunnion hoop | 0.0153 | 0.0174 | +0.0021 |
| III sub. | | ............ | 0.0184 | ............ |
| IV | Shoulder of jacket | 0.0142 | 0.0181 | +0.0039 |
| V | To end of A row | 0.0151 | 0.0161 | +0.0010 |
| VI | To end of D row | 0.0122 | 0.0127 | +0.0005 |
| VII | To second shoulder on tube | 0.0076 | 0.0085 | +0.0009 |
| VIII | Joint $C_1$ and $C_2$ | 0.0062 | 0.0071 | +0.0009 |
| IX | Near muzzle of mortar | 0.0055 | 0.0054 | —0.0001 |

## EXPANSION OF JACKET AND HOOPS BY HEAT FOR SHRINKAGE.

The details of the heating and shrinking are given in the accompanying table, with the corresponding expansions and temperatures. The openings at the joints are also given in the record of shrinkage operations.

These openings were measured at four points, marked 1, 2, 3, and 4, 90° apart.

The mortar after being finished was shipped to the Ordnance Proving Ground at Sandy Hook, N. J.

In rifling an accident occurred to the rifling machine, by which the cutters were thrown out of their cut, and four scores were made across the lands for a distance of about 14 inches. The forward edges of these scores were beveled off to reduce the chances of stripping the lands.

The plates accompanying the report show the details of the construction.

The following tables and plates accompany the report:

### TABLES.

(1) Inspection report.
(2) Record of shrinkage operations.
(3) Summary of effects of shrinkage.

### PLATES.

(I) Elevation and section of mortar.
(II) Details of breech bushing, hoops and joints, chamber and rifling.
(III) Details of breech mechanism; block unlocked.
(IV) Details of breech mechanism; rotating gear and tray.
(V) Details of breech mechanism; translating roller, etc.
(VI) Details of breech mechanism; face plate, spindle, etc.
(VII) Shrinkages, curves of resistances, and compressions.

(5055–'91.)

*Report of inspection and proof of 12-inch B. L. mortar (steel), No. ——, manufactured at the Watervliet Arsenal, West Troy, N. Y., under orders of the Chief of Ordnance, U. S. Army, dated August 20, 1890.*

[Dimensions given in inches, unless otherwise expressed. Where no sign is prefixed to the figures given in the column of allowed variations the double sign, plus or minus, will be understood.]

| Subject of measurement. | Dimensions. | | Variations. | |
|---|---|---|---|---|
| | Prescribed. | Actual. | Allowed. | Actual. |
| Total length of gun over all, breech closed | 141.125 | 141.190 | 0.10 | +0.065 |
| Length— | | | | |
| From muzzle to first step | 60.625 | 60.740 | 0.05 | +0.050 |
| From muzzle to second step | 72.625 | 72.700 | 0.05 | +0.075 |
| From muzzle to front of trunnion hoop | 83.125 | 83.200 | 0.05 | +0.075 |
| From muzzle to axis of trunnions | 90.125 | 90.200 | —0.05 | +0.075 |
| From breech to axis of trunnions | 51.000 | 50.990 | +0.05 | +0.010 |
| Of trunnion hoop | 14.000 | 14.004 | 0.01 | +0.004 |
| Of trunnions right | 8.000 | 8.000 | 0.01 | 0 |
| left | 8.000 | 7.999 | 0.01 | —0.001 |
| Of rimbases | 0.750 | 0.750 | 0.02 | 0 |
| Of tube, total | 125.625 | 125.690 | 0.05 | +0.065 |
| Of true bore, cylindrical | 65.100 | 65.100 | 0.05 | 0 |
| Of conical bore | 30.000 | 30.000 | 0.05 | 0 |
| Of rifling | 95.100 | 95.100 | 0.05 | 0 |
| Of chamber slope | 4.200 | 4.200 | 0.025 | 0 |
| Of powder chamber, cylindrical | 23.450 | 23.450 | 0.02 | 0 |
| Of gas-check seat | 2.875 | 2.875 | 0.02 | 0 |
| Of bore from front of spindle, breech closed | 119.500 | 119.520 | 0.05 | +0.020 |
| Of breech recess | 15.500 | 15.435 | 0.01 | —0.065 |
| Of thread in breech recess | 13.600 | 13.600 | 0.02 | 0 |
| Of spindle, total | 21.375 | 21.375 | 0.02 | 0 |
| Between front faces of spindle and breechblock | 5.725 | 5.725 | 0.02 | 0 |
| Of breechblock and banjo, handles excluded* | 17.950 | 17.942 | 0.01 | —0.008 |
| Of thread on block, top line | 12.560 | 12.564 | 0.02 | +0.004 |
| Of jacket, total | 70.125 | 70.125 | 0.03 | 0 |
| Of C hoops, total | 71.000 | 71.064 | 0.03 | +0.064 |
| Of D hoops, total | 18.000 | 18.000 | 0.03 | 0 |
| Of A hoops, total | 68.500 | 68.504 | 0.03 | +0.004 |
| Of B hoops, total | None. | .......... | 0.03 | .......... |
| Distance between rimbases, out to out | 40.000 | 39.980 | 0.04 | —0.020 |
| Diameter— | | | | |
| Of true bore, across lands | 12.000 | 12.0045 to 12.009 | +0.003 | +0.009 |
| Of conical bore, rear | 12.070 | 12.070 | +0.003 | 0 |
| Of gas-check seat, rear | 12.750 | 12.750 | (†) | 0 |
| Of breech recess in slots | 14.520 | 14.519 | +0.005 | —0.001 |
| Of breech recess at bottom of threads | 14.500 | 14.499 | 0.002 | —0.001 |
| Of breech recess at top of threads | 13.860 | 13.859 | 0.002 | —0.001 |
| Of breechblock in slots | 13.800 | 13.800 | —0.005 | 0 |
| Of breechblock at bottom of threads | 13.825 | 13.825 | 0.002 | 0 |
| Of breechblock at top of threads | 14.465 | 14.465 | 0.002 | 0 |
| Of head of spindle, maximum | 12.450 | 12.450 | 0.005 | 0 |
| Of stem of spindle | 3.210 | 3.212 | .......... | +0.002 |
| | 3.960 | 3.959 | 0.002 | —0.001 |
| Of powder chamber | 12.500 | 12.501 to 12.5035 | 0.003 | +0.0035 |
| Of vent in spindle | 0.200 | 0.200 | 0.002 | 0 |
| Of vent in copper bushing | 0.100 | 0.100 | 0.002 | 0 |
| Pitch of thread in breech | 0.960 | 0.960 | .......... | 0 |
| Number— | | | | |
| Of sectors in breech | 3 | 3 | .......... | 0 |
| Of rifling grooves and lands, each | 72 | 72 | .......... | 0 |
| Width— | | | | |
| Of grooves | 0.3736 | 0.3736 | 0.002 | 0 |
| Of lands | 0.150 | 0.150 | 0.002 | 0 |
| Depth of grooves | 0.070 | 0.0695 | +0.003 | —0.0005 |
| Twist of rifling— | | | | |
| At origin, one turn in calibers ‡ | 40 | 40 | .......... | 0 |
| At 17.100 inches from muzzle, calibers § | 20 | 20 | .......... | 0 |
| Diameters on exterior of tube—‖ | | | | |
| Breech to first shoulder | 20.000 | 19.9965 | 0.01 | —0.035 |
| First to second shoulder | 19.500 | 19.4995 | 0.01 | —0.005 |
| Second to third shoulder | 18.800 | 18.800 | 0.01 | 0 |
| Third shoulder to muzzle | 18.000 | 18.000 | 0.01 | 0 |

* Includes face plate.

† To fit gauge.

‡ Increasing.

§ Uniform to muzzle.

The measurements entered here are the interior diameters of jacket, etc., which differ from the exterior of tube by the amount of shrinkage.

*Report of inspection and proof of 12-inch B. L. mortar (steel), No. ——, etc.*—Continued.

| Subject of measurement. | Dimensions. | | Variations. | |
|---|---|---|---|---|
| | Prescribed. | Actual. | Allowed. | Actual. |
| Diameters on exterior of jacket—[*] | | | | |
| Breech to first shoulder | 30.500 | 30.498 | 0.01 | —0.002 |
| First to second shoulder | 31.500 | 31.4985 | 0.01 | —0.0015 |
| Second shoulder to muzzle | 26.600 | 26.6005 | 0.01 | +0.0005 |
| Diameter on exterior of A hoops [†] | 38.000 | 38.000 | 0.01 | 0 |
| Diameters on exterior of C hoops [‡] | 26.600 | 26.6005 | ......... | +0.0005 |
| Muzzle of jacket to first shoulder | 26.600 | 26.6005 | 0.01 | +0.0005 |
| Exterior of D hoops | 31.500 | 31.499 | 0.01 | —0.001 |
| Diameter— | | | | |
| Of trunnion hoop, exterior | 38.500 | 38.550 | ......... | +0.050 |
| Of trunnions, right | 12.000 | 12.000 | 0.01 | 0 |
| Of trunnions, left | 12.000 | 12.000 | 0.005 | 0 |
| Of gun over reinforce, exterior | 38.000 | 38.000 | 0.005 | 0 |
| Of gun in front of trunnion hoop | 37.000 | 37.002 | 0.01 | +0.002 |
| Of gun in front of A hoops | 32.500 | 32.496 | 0.01 | —0.004 |
| Of gun in front of D hoops | 26.000 | 26.000 | 0.01 | 0 |
| Of gun at muzzle, off round | 21.000 | 21.002 | 0.01 | +0.002 |
| Axis of trunnions above (below) axis of gun | 0 | 0 | 0.01 | 0 |
| Weight— | *Pounds.* | *Pounds.* | *Pounds.* | *Pounds.* |
| Of breech block with face plate. revolving crank, gears, pinion, and vent cover | ......... | 730½ | ......... | ......... |
| Of console with tray latch, translating roller, and translating crank | ......... | 200 | ......... | ......... |
| Of hinge pin with nut and washer | ......... | 16 | ......... | ......... |
| Of spindle | ......... | 138 | ......... | ......... |
| Of gas-check cups and pad | ......... | 38 | ......... | ......... |
| Of washers and nuts | ......... | 13 | ......... | ......... |
| Of gun without fermeture | ......... | 27,835½ | ......... | ......... |
| Total weight of gun | 29,120 | 28,971 | ......... | —149 |
| Preponderance at face of breech, gun complete | ......... | —63 | ......... | — 63 |

[*] Interior diameters of A hoops, etc.
[†] Interior diameter of B hoops, etc.
[‡] Interior diameters of D hoops, etc.

Marks on finished gun: 12-inch No. 1; weight 13 tons 28.971 pounds. L. L. B., inspector. Watervliet Arsenal.

Material (designated by the marks of the inspectors of material): Tube, 12 M. R., 1 T.; jacket, 12 M. R., 1 T. Hoops: $A_1$, 12 M. R., 1 $A^1$; $A_2$ (TH), 12 M. R., 1 TH.; $A_3$, 12 M. R., 1 $A^3$; $C_1$, 12 M. R., 1 $C^1$; $C_2$, 12 M. R., 1 $C^2$; $D_1$, 12 M. R., 1 $D^1$. Breech parts: BU, 12 M. R., 1 BU; BB, 12 M. R., 1 BB; SP, 12 M. R., 1 SP.; GC, 12 M. R., 1 GC; HP, 12 M. R., 1 HP; TrR, 12 M. R., 1 TrR.

I certify that the foregoing report is correct, and that the 12-inch rifle and mortar therein specified has been accepted by me as conforming to the standards as to dimensions, quality of material, and character of workmanship prescribed by the Ordnance Department.

Date of inspection, June 22 and 24, 1891.

LAWRENCE L. BRUFF,
*Captain, Ord. Dept., U. S. Army, Inspector.*

*Record of inspection of 12-inch B. L. steel mortar, No. 1, manufactured at Watervliet Arsenal, West Troy, N. Y., under orders of the Chief of Ordnance, U. S. Army.*

## RECORD OF SHRINKAGE OPERATIONS.

| Jacket and hoops. | Intervals of time. | | | | | Expansion and temperature of metal. | | | | | | Openings at joints in cooling. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Prescribed expansions. | | | Final expansions. | | | | | | | |
| | In furnace heating. | Furnace to position. | Position to pressure applied. | Furnace to water on. | Water applied. | Gauge-rod set. | Expansion. | Clearance. | Absolute. | Relative. | Highest temperature. | 1 | 2 | 3 | 4 | Average. |
| | *H. M.* | *H. M.* | *H. M.* | *H. M.* | *H. M.* | *Inches.* | *Inch.* | *Inch.* | *Inch.* | *Per inch.* | *F°.** | *Inch.* | *Inch.* | *Inch.* | *Inch.* | *Inch.* |
| Hoop A¹ | 2 30 | 0 4 | 0 ¾ | 0 5 | 0 36 | 31.610 | 0.110 | 0.071 | 0.110 | 0.0034 | 485 | 0.007 | 0.007 | 0.010 | 0.005 | 0.007 |
| Hoop A² | 2 27 | 0 5 | 0 1 | 0 6 | 1 12 | 30.610 | 0.110 | 0.072 | 0.110 | 0.0036 | 514 | 0.007 | 0.015 | 0.005 | 0.005 | 0.008 |
| Hoop A³ | 2 36 | 0 8 | 0 1 | 0 46 | 1 10 | 30.610 | 0.110 | 0.072 | 0.110 | 0.0036 | 514 | 0.007 | 0.005 | 0.009 | 0.010 | 0.008 |
| Hoop C¹ | 1 54 | 0 5 | 0 ½ | 0 6 | 0 57 | 19.580 | 0.080 | 0.055 | 0.080 | 0.004 | 571 | 0.002 | 0.003 | 0.004 | 0.003 | 0.003 |
| Hoop C² | 1 45 | 0 13 | 0 1 | 0 14 | 1 5 | 18.870 | 0.070 | 0.052 | 0.070 | 0.0037 | 527 | 0.015 | 0.008 | 0.008 | 0.014 | 0.010 |
| Hoop D¹ | 4 0 | 0 6 | 0 2 | 0 9 | 1 0 | 26.706 | 0.106 | 0.077 | 0.106 | 0.0039 | 557 | 0.005 | 0.006 | 0.005 | 0.006 | 0.0055 |
| Jacket | 5 45 | 0 13 | 0 2 | 0 16 | 3 0 | 20.087 | 0.087 | 0.069 | 0.087 | 0.0043 | 614 | 0.002 | 0.003 | 0.004 | 0.003 | 0.003 |

* To be estimated. Divide the expansion per inch by 0.000007.

LAWRENCE L. BRUFF,
*Captain, Ord. Dept., U. S. Army, Inspector.*

*Summary of effects of shrinkage of 12-inch B. L. mortar*

| | Sections of mortar. | | Diameters of jacket or hoops. | | | Shrinkages. | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Exterior. | | Interior. | | Prescribed. | | |
| | Designation. | Limits, distance from breech. | Actual. | Prescribed. | Prescribed. | Order of. | Relative. | Absolute. | Allowed variation. |
| | | *Inches.* (1) | *Inches.* (2) | *Inches.* (3) | *Inches* (*a*) | (5) | *Thousandths.* *b* | *Inch.* *a*×*b* | *Inch.* (8) |
| I | Breech recess.......... | 0–15.5 | 38.132 | 38.0 | 30.5 | 2d... | 1.0783 | 0.0329 | +0.001<br>—0.002 |
| II | Powder chamber....... | 15.5–44.0 | 31.05 | 30.5 | 20.0 | 1st.. | 1.0887 | 0.0214 | +0.002<br>—0.001 |
| | | | 38.132 | 38.0 | 30.5 | 2d... | 1.2766 | 0.0389 | +0.001<br>—0.002 |
| III | Trunnion hoop. III ........ | 44.0–54.0 | 31.05 | 30.5 | 20.0 | 1st.. | 1.0887 | 0.0214 | +0.002<br>—0.001 |
| | | | 38.5 | 38.5 | 30.5 | 2d... | 1.2628 | 0.0385 | +0.001<br>—0.002 |
| | III *sub*..... | 54.0–58.0 | 31.05 | 30.5 | 19.5 | 1st.. | 1.0887 | 0.0212 | +0.002<br>—0.001 |
| | | | 38.5 | 38.5 | 30.5 | 2d... | 1.2628 | 0.0385 | +0.001<br>—0.002 |
| IV | Shoulder of jacket..... | 58.0–62.5 | ......... | 31.5 | 19.5 | 1st.. | 1.0996 | 0.0214 | +0.002<br>—0.001 |
| | | | | 37.0 | 31.5 | 2d... | 1.2932 | 0.0407 | +0.001<br>—0.002 |
| V | To end of A row....... | 62.5–68.5 | 27.041 | 26.6 | 19.5 | 1st.. | 1.0985 | 0.0214 | +0.002<br>—0.001 |
| | | | 31.606 | 31.5 | 26.6 | 2d... | 1.0672 | 0.0284 | +0.001<br>—0.002 |
| | | | Tapered | 36.0 | 31.5 | 3d... | 0.9817 | 0.0310 | |
| VI | To end of D row....... | 68.5–80.5 | 26.7 | 26.6 | 19.5 | 1st.. | 1.0985 | 0.0214 | +0.002<br>—0.001 |
| | | | Tapered | 32.5 | 26.6 | 2d... | 1.0672 | 0.0284 | +0.001<br>—0.002 |
| VII | To 2d shoulder on tube. | 80.5–92.0 | Tapered | 26.6 | 19.5 | 1st.. | 1.0985 | 0.0214 | +0.002<br>—0.001 |
| VIII | Joint $C_1$ and $C_2$........ | 92.0–116.0 | Tapered | 24.3 | 18.8 | 1st.. | 1.0262 | 0.0193 | +0.001<br>—0.002 |
| IX | Near muzzle of gun.... | 116.0–141.125 | Tapered | 22.4 | 18.0 | 1st.. | 0.9496 | 0.0171 | +0.001<br>—0.002 |

NOTES IN REGARD TO MEAN VALUES OF ACTUAL SHRINKAGES AND COMPRESSIONS OF BORE.

Columns *c* and *e* taken from Form 40E.

SHRINKAGES.

Section II.—First shrinkage, omit 6.″0 (15.5–20.5) reduced shrinkage. Second shrinkage, omit 2.″5 (15.5–17.0) for conical surface.

Section III *sub*.—There are no computations for the particular diameter occurring in this length. The first shrinkage (relative) of III extends over III *sub*. It is placed separately in the summary to show actual measurements only.

Section IV.—Second shrinkage, omit 2.″0 (60.5–61.5) for conical surface.

Section V.—Third shrinkage, omit 2.″0 (62.5–63.5) for conical surface.

Section IX.—The conical shrinkage surface (131–141.125) is included, the final value of the record being assumed as the average.

*(steel), No. 1, at Watervliet Arsenal, December 8, 1890.*

| Shrinkages, actual (measured). | | | Diameters of bore. | | | Compression of bore. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Before shrinkage. | | After shrinkage. | Actual. | | Computed. | | Variation from actual. | Estimated, including initial tension for cast-iron steel-hooped mortars. |
| Absolute. | Per cent of prescribed. | Variation. | Prescribed. | Actual. | Actual. | Measured. | Relative. | From prescribed shrinkages. | From actual shrinkages. | | |
| *Inch.* $c$ | *P. ct.* $\frac{c}{a.b}$ | *Inch.* $c-a,b$ | *Inches* (12) | *Inches.* $d$ | *Inches.* | *Inch.* $e$ | *Thousandths.* $\frac{e}{d}$ | *Inch.* $f$ | *Inch.* $f\frac{e}{a.b}$ | *Inch.* $e-f\frac{e}{a.b}$ | *Pounds per square in.* $\left(\begin{matrix}\text{Mod-}\\\text{ulus.}\end{matrix}\right\}\times\frac{e}{d}\Big)+\text{I. T.}^*$ |
| 0.0317 | 98.4 | —0.0006 | 20.9 | 19.9977 | 19.9895 | 0.0082 | 0.4100 | 0.0110 | 0.0106 | —0.0024 | 12,300 |
| 0.0217 | 101.4 | +0.0003 | 12.5 | 12.3977 | 12.3875 | 0.0102 | 0.8227 | 0.0092 | 0.0093 | +0.0009 | 24,681 |
| 0.0402 | 103.3 | +0.0013 | ...... | ........ | 12.3827 | 48 | 0.3872 | 63 | 65 | —0.0017 | 11,616 |
| | | | | | | 0.0150 | 1.2099 | 0.0155 | 0.0158 | —0.0008 | 36,297 |
| 0.0222 | 102.7 | +0.0006 | 12.0 | 11.8014 | 11.7893 | 0.0121 | 1.0253 | 0.0087 | 0.0090 | +0.0031 | 30,759 |
| 0.0399 | 103.6 | +0.0014 | ...... | ........ | 11.7840 | 53 | 0.4491 | 61 | 63 | —0.0010 | 13,473 |
| | | | | | | 0.0174 | 1.4744 | 0.0148 | 0.0153 | +0.0021 | 44,232 |
| 0.0209 | ...... | —0.0003 | 12.0 | 11.8009 | 11.7885 | 0.0124 | 1.0508 | ...... | ...... | ........ | 31,524 |
| 0.0399 | ...... | +0.0014 | ...... | ........ | 11.7825 | 60 | 0.5084 | ...... | ...... | ........ | 15,252 |
| | | | | | | 0.0184 | 1.5592 | ...... | ...... | ........ | 46,776 |
| 0.0213 | 99.5 | —0.0001 | 12.0 | 11.8007 | 11.7889 | 0.0118 | 0.9999 | 0.0094 | 0.0094 | +0.0024 | 29.997 |
| 0.0412 | 101.5 | +0.0006 | ...... | ........ | 11.7826 | 63 | 0.5339 | 47 | 48 | +0.0015 | 16,017 |
| | | | | | | 0.0181 | 1.5338 | 0.0141 | 0.0142 | +0.0039 | 46,014 |
| 0.0223 | 104.2 | +0.0009 | 12.0 | 11.8003 | 11.7900 | 0.0103 | 0.8729 | 0.0075 | 0.0078 | +0.0025 | 26,187 |
| 0.0271 | 95.4 | —0.0013 | ...... | ........ | ........ | ........ | ........ | ...... | ...... | ........ | .................... |
| 0.0310 | 100.0 | ±0.0000 | ...... | ........ | 11.7842 | 58 | 0.4915 | 0.0073 | 73 | —0.0015 | 14,745 |
| | | | | | | 0.0161 | 1.3644 | 0.0148 | 0.0151 | +0.0010 | 40,932 |
| 0.0216 | 100.9 | +0.0002 | 12.0 | 11.8000 | 11.7905 | 0.0095 | 0.8051 | 0.0075 | 0.0076 | +0.0019 | 24,153 |
| 0.0274 | 96.5 | —0.0010 | ...... | ........ | 11.7873 | 32 | 0.2712 | 48 | 46 | —0.0014 | 8,136 |
| | | | | | | 0.0127 | 1.0763 | 0.0123 | 0.0122 | +0.0005 | 32,289 |
| 0.0216 | 100.9 | +0.0002 | 12.0 | 11.7988 | 11.7903 | 0.0085 | 0.7204 | 0.0075 | 0.0076 | +0.0009 | 21,612 |
| 0.0189 | 97.9 | —0.0004 | 12.0 | 11.8001 | 11.7930 | 0.0071 | 0.6021 | 0.0064 | 0.0062 | +0.0009 | 18,063 |
| 0.0169 | 98.8 | —0.0002 | 12.0 | 11.8004 | 11.7950 | 0.0054 | 0.4578 | 0.0056 | 0.0055 | —0.0001 | 13,734 |

* Modulus = 30,000,000 pounds. Initial tension for steel tube taken = zero.

COMPRESSIONS OF BORE.

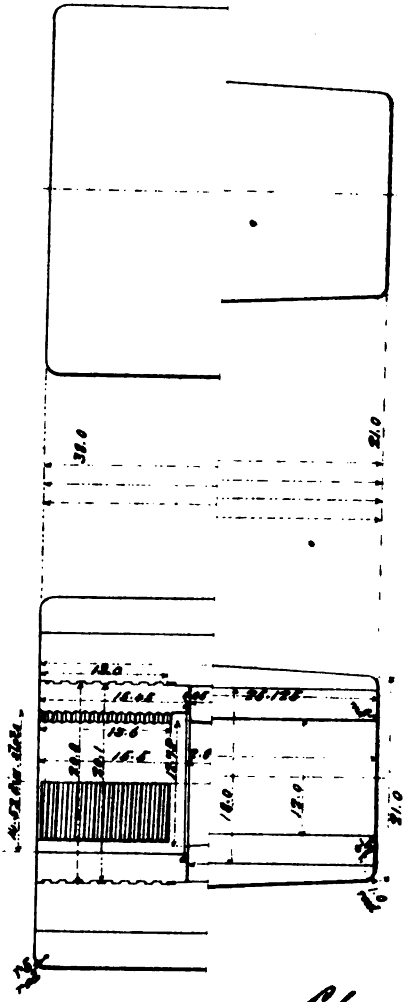
Section II.—Omit 6."0 (15.5–20.5) of reduced first shrinkage.

Sections II and III.—Omit the length 4."2, extending from 41.0–46.0, over front slope of powder chamber, not measured for compression.

Section V.—Compressions due to second and third shrinkages were measured together and the comparison is made accordingly.

Section VIII.—The increase of compression due to assemblage of $D_1$, which extends over this section, is added to the compression.

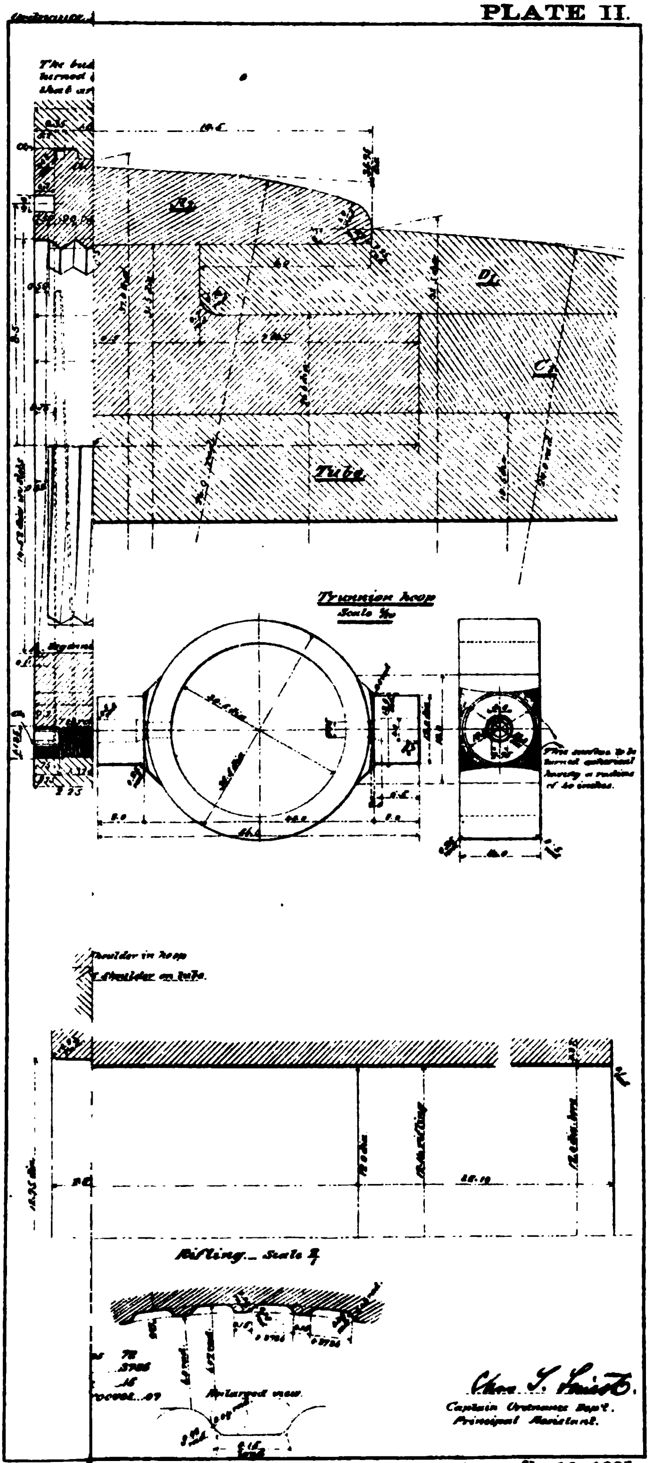
Ordnance Dep't. U. S. A., April 8 PLATE I.



Chas S. Smith

Captain Ordnance Dep't.,
Principal Assistant.

PLATE II.



Chas. S. Smith.
Captain Ordnance Dep't.
Principal Assistant.

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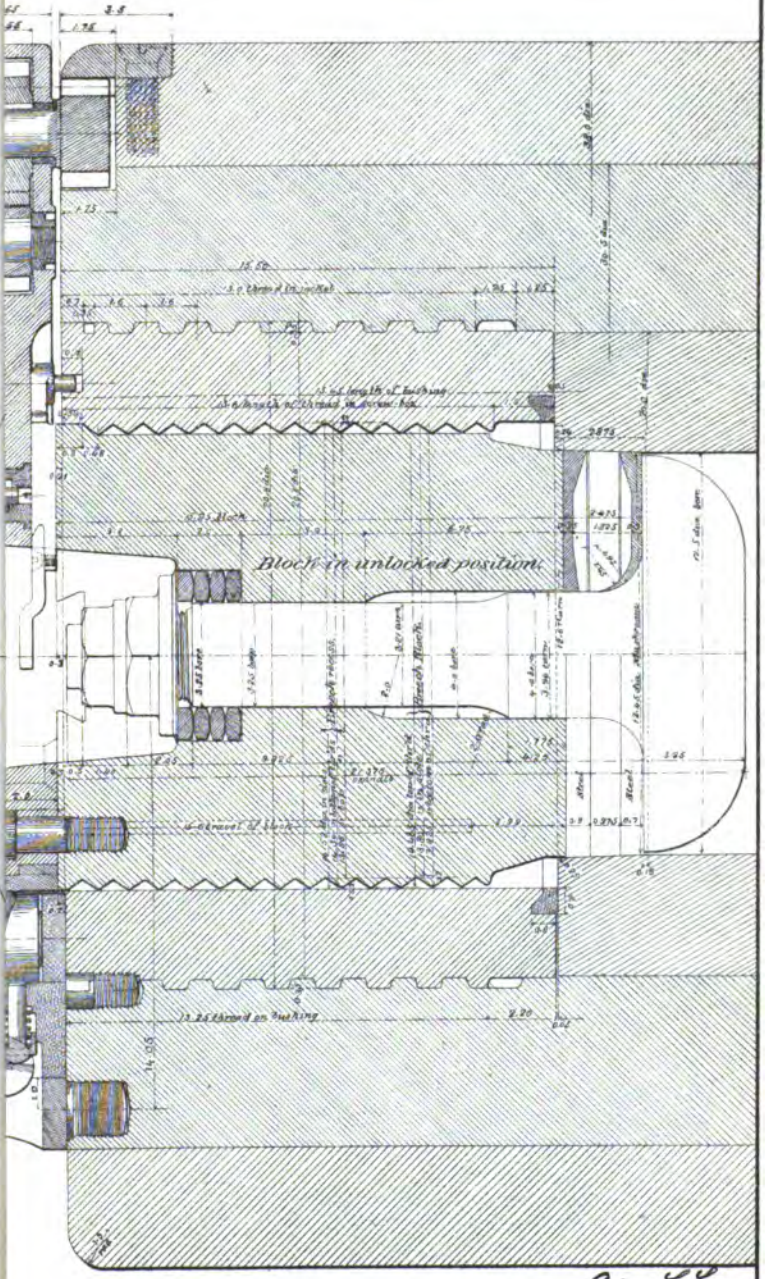
Appendix 18 1891.



Chas S. Smith

Captain Ordnance Dept.,
Principal Assistant

Fig. 8 to 14a, Hinge Block.
Steel.

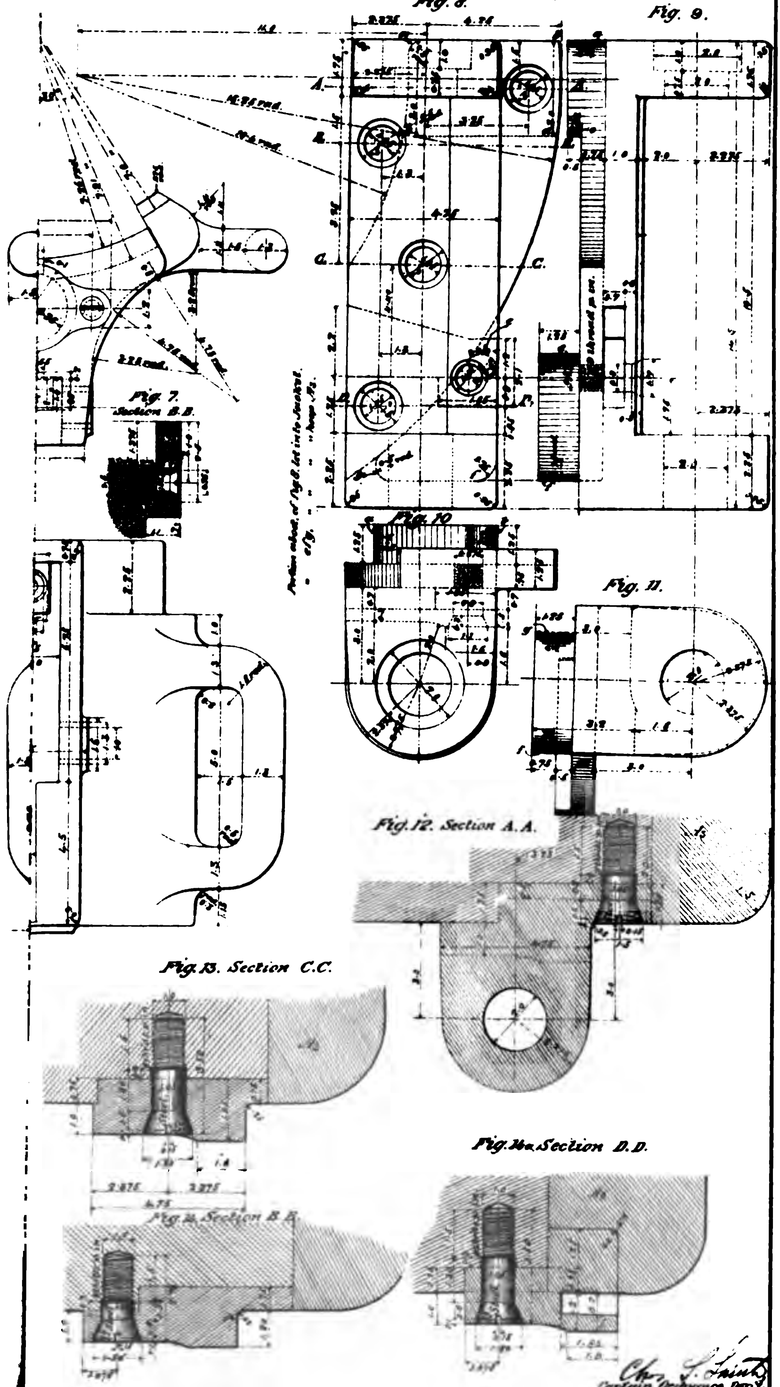


Fig. 7. Section B.B.

Fig. 8.

Fig. 9.

Fig. 10.

Fig. 11.

Fig. 12. Section A.A.

Fig. 13. Section C.C.

Fig. 14. Section B.B.

Fig. 14a. Section D.D.

Chas. S. Smith
Captain Ordnance Dep't.
Principal Assistant.

# PLATE V.

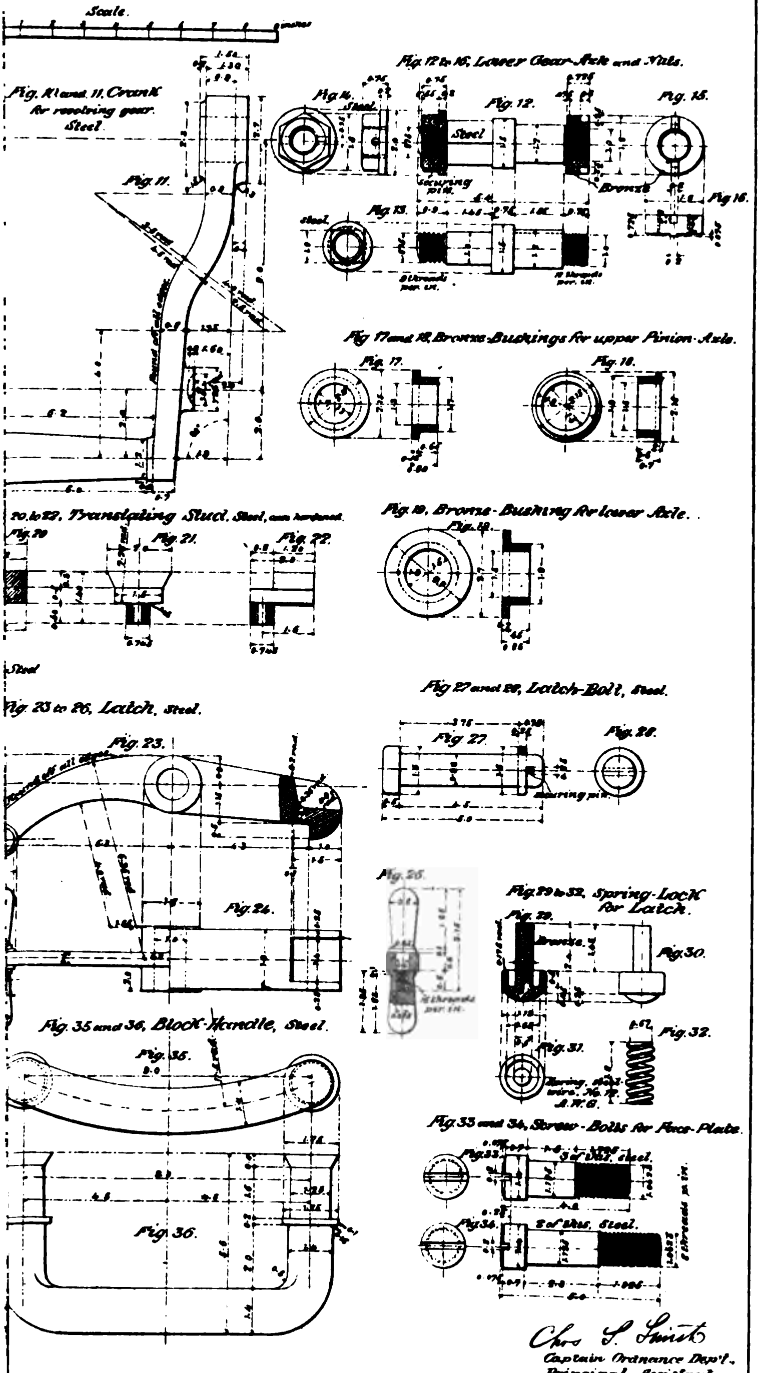


Fig. 10 and 11. Crank for revolving gear. Steel.

Fig. 12 to 16. Lower Gear-Axle and Nuts.

Fig 17 and 18. Bronze-Bushings for upper Pinion-Axle.

20. to 22. Translating Stud. Steel, case hardened.

Fig. 19. Bronze-Bushing for lower Axle.

Fig. 23 to 26. Latch, steel.

Fig 27 and 28. Latch-Bolt, steel.

Fig 29 to 32. Spring-Lock for Latch.

Fig. 35 and 36. Block-Handle, Steel.

Fig 33 and 34. Screw-Bolts for Face-Plate.

Chas. S. Smith
Captain Ordnance Dep't.,
Principal Assistant

Appendix 18 1891.

and Gas-check Cups.

le.

nlarged view of end of Cups.

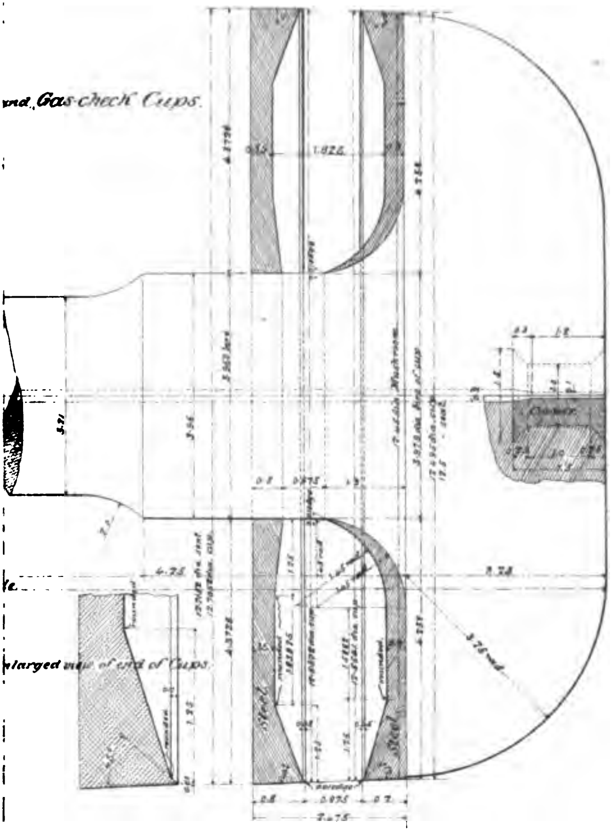


Fig. 7, Side-view.

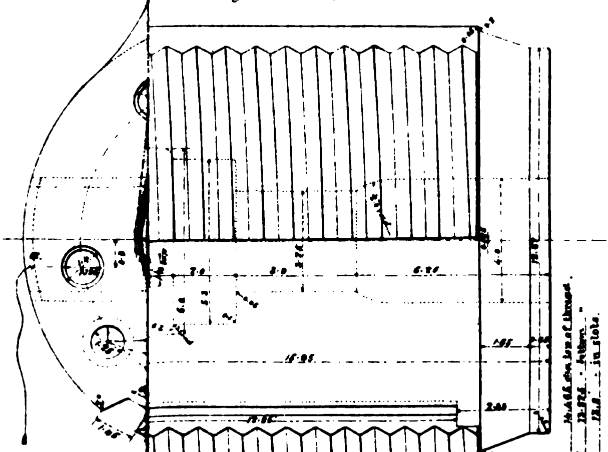
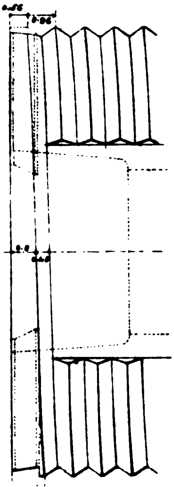
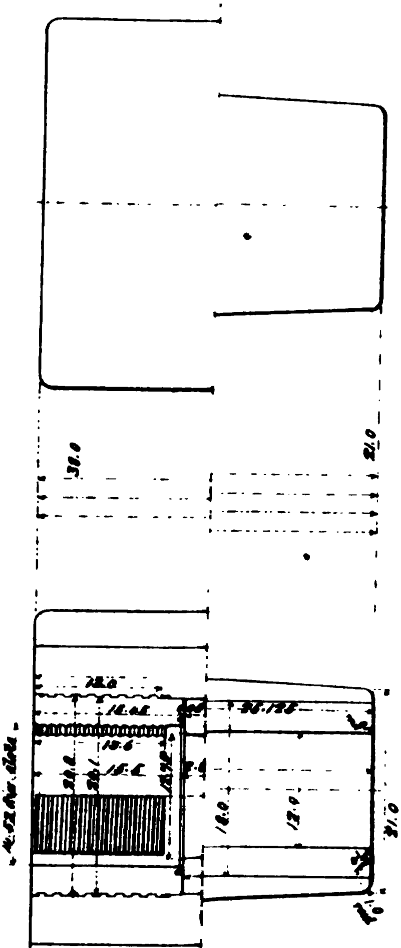


Fig. 8, Top-view.



The inner edge of circ
face-plate is to be bevel
the bevel of thread on
shown at "a"

Chas. S. Smith
Captain Ordnance Dep't.,
Principal Assistant.



*Chas. S. Smith.*

*Captain Ordnance Dep't.,*
*Principal Assistant.*

# APPENDIX 19.

## *FRANKFORD ARSENAL POINT COMBINATION FUSE WITH CHANNEL TIME TRAIN, DEVISED BY LIEUT. COL. D. W. FLAGLER, ORDNANCE DEPARTMENT.*

(One plate.)

### REPORTS BY LIEUT. COL. D. W. FLAGLER.

FRANKFORD ARSENAL, PA., *November 5, 1887.*

Referring to my letter of this date in regard to my proposed combination fuse for the 3.2-inch rifle field gun projectiles, I have the honor to state that a principal feature of the percussion part of the fuse is the release of the plunger from its fastenings at the moment of firing, in order that it may be free to move on impact. If the shock of impact is required to break the plunger fastenings it leaves only a portion (possibly a small portion) of the inertia of the plunger for furnishing the blow required for exploding the primer. The object sought is to insure the action of the fuse on striking soft objects, such as mud, sand, or water, or on striking on its side.

The method adopted for breaking the plunger fastenings at the moment of firing is the torsional strain of the plunger due to the rotation given to the projectile. My experiments show that by this method the plungers can be more securely fastened (against accident in handling and transportation) and still leave a wider margin between their strength and the strains caused by firing. It is proposed to employ the same method for the time-part plunger also. (The fastenings are also left exposed to all the strains due to change of velocity of translation, as in other fuses.)

I have tested the mechanism of the fuses carefully by dropping from a height, and have also by experiment reproduced by mechanical devices the calculated torsional strains of firing, but before preparing expensive molds for making the fuses I deem it important that the mechanism should be tested by actual firing.

I have made seven specially prepared plugs for this purpose, and respectfully ask that they may be tried at Sandy Hook. I would also respectfully request that I may be present to witness the trial. I think it may be necessary to fire from 10 to 15 rounds at velocities below service velocities, and would like to examine the mechanism immediately after firing to determine fully the tests that are necessary.

FRANKFORD ARSENAL, PA., *February 11, 1889.*

With a view of obtaining accurate results in burning channels and compositions of time fuses I have the honor to make the following report and suggestions:

Most of the firing experiments with my fuse have been for testing small details to determine required strength of parts, required sensitiveness, testing new devices, etc., with the one object of perfecting the mechanism of the fuse and of making it conform to dimensions required by the Department.

So far as I can judge from the results of the firings I think the mechanical part of the fuse is now perfected.

It was not practicable to undertake perfecting the burning channels and compositions to obtain accurate time for the time parts until the mechanism for operating the fuse was perfected.

Experiments for improving burning compositions and channels have been in progress at the same time, and especially for charging the channels with uniform density, and then for obtaining uniform compression by weighing the same. Some of the small tube manufactured abroad has also been made, and good results obtained with it as regards uniformity of rate of burning. Having no samples and lack of full knowledge of mode of manufacture has delayed this work. Especially. having no sample, the method employed for setting the time of the fuse and for cutting and igniting the composition could not be determined.

I have, however, devised a method which gives satisfactory results so far, and I think fuses having this foreign tube, and also some having new and better compositions compressed with a weighing press in our regular "horseshoe" channel, can be ready for trial this month.

In regard to these time trials I respectfully ask attention to the following:

The results thus far obtained indicate that with the new compositions and perfected methods of charging uniform accuracy of rate of burning can be obtained for at rest.

I have fitted the Schultz chronoscope for timing these burning compositions, the foreign tube, and fuses made from both, so that the rate of burning can be recorded accurately to $\frac{1}{100}$ second.

The above, however, is the time of burning at rest. The time of burning while a projectile is in flight is less. For the same velocity the latter is the former multiplied by a constant. I think experiments should be made to determine this constant, say for two or three velocities. It could then be calculated with sufficient accuracy for all velocities used in service.

Having these constants the accurate appliances here for timing burning compositions would furnish all the data that is needed for the accurate graduation of all time fuses in the future, and I believe this data can not be determined accurately in any other way.

It would seem on first consideration that timing with stop watches in actual firing would be a better way, but I believe it is not. What I have seen of this method leads me to believe it is at best uncertain, and is not sufficiently accurate. Any doubt of the accuracy of a record is very trying.

The appliances here can give quickly, without expense, reliable and accurate record of the rate of burning at rest. With the above constant once obtained for reducing this to rate of burning in flight the required graduation could always be determined at once without further expense.

As to the best method of obtaining this constant I would respectfully recommend the following:

First. If distant stations or poles were set up along the line of fire, and observers stationed opposite them, the point at which the fuse explodes could be observed accurately. Having also the muzzle velocity, the time to the point of explosion can then be calculated with close accuracy.

Second. Having ascertained the point at which the fuse will explode, the above record might be perhaps further corrected by setting up a velocity target in front of the predetermined point of explosion, and taking time with a Schultz to the target, and calculating the time for only the short distance from the target to the observed point of explosion. I believe, however, this correction would be unnecessary.

Third. If the above data were determined for two or three velocities the required constant could then be calculated with sufficient accuracy for other velocities.

FRANKFORD ARSENAL, PA., *June 20, 1889.*

In obedience to your instructions of the 6th instant, I have the honor to report that ten of my new combination fuses, for use in testing 3.2-inch steel-case shrapnel, have been sent to the commanding officer of the United States proving ground, care New York Arsenal.

The trials of the fuse which have been made indicate that both the percussion and time part of the fuse (excepting the rate of burning, which is the subject of this letter) are sufficiently perfect, and I trust no further material changes in them will be found necessary.

I think some suggestions in regard to rate of burning may be of use in the trial of the shrapnel, in order to procure explosion of the latter at the particular point desired.

With improved methods of preparing the burning composition and of charging and compressing it into the burning channel, results have been obtained during the past year which the very accurate timing by instruments here showed to be extremely uniform.

I found, however, that the rate of burning in a projectile in flight (which I will call rate of burning in flight) was greater than the rate of burning here (which I will call rate of burning at rest). The difference in rate should be practically uniform for the same velocity. I had no data in regard to the amount of this difference, and in most of the trials at Sandy Hook have been trying to arrive at it. I finally found that the method of timing at Sandy Hook, with timers, was not sufficiently accurate for this purpose, and in my letter of February 11, 1889, I suggested a method for observing the point of explosion, and then that the time to the point of explosion be calculated. This was done, and gave the time with extreme accuracy. It was found that fuses set to the same time exploded uniformly within about 50 feet of the same point, with a range of 2,000 yards. This showed extraordinary uniformity of rate of burning in flight. The results obtained in this way show the time in flight to be only 80 or 81 per cent of the time at rest. To avoid confusion the graduation on the fuses was made uniformly the time of burning at rest here.

The above correction of 20 per cent applied to the records of firing of the time part of the fuse at Sandy Hook shows extremely accurate results (allowing for some errors in the method of timing).

Careful consideration, however, leads me to believe that duration and conditions of storage will affect and change the rate of burning.

It is also probable that wind and the condition of the atmosphere will affect the rate of burning. We know they affect velocity, and through it they certainly affect the time to the point fixed for explosion.

If it is the velocity that affects the rate of burning in flight so greatly as to increase it 20 per cent, then, since the velocity varies throughout the flight, the rate of burning will vary also.

It is not possible to make and compress the composition so that it will always give precisely the same rate of burning, but timing each lot or every day's manufacture, and graduating accordingly, will overcome this last source of variation.

We must conclude, therefore, that however perfect the burning composition and channel, the graduation can not be made to agree exactly with the rate of burning in flight.

Fortunately it is a matter of no importance to the artillerist that they should agree exactly. It is desirable that they should agree nearly, and I think they can be made to agree much more nearly than is necessary.

What the artillerist requires is great uniformity in the rate of burning in the same fuse, and that for a lot of fuses used at one time, when set to the same time (or point of graduation), they will explode at the same point.

The artillerist draws on his experience and guesses at the time to the point required and fires a trial shot. If he can see the explosion (which he generally can not) and finds he guessed too much time, he lessens it, and *vice versa;* and goes on thus till he "gets his range." If he guessed within 25 per cent on the battlefield, the first time, it was a good guess. It is totally unnecessary therefore that the actual fuse time should coincide exactly with the inaccurately guessed time. It is desirable that it should coincide nearly, which it will do. It is, however, necessary that the fuse should burn uniformly, that it may respond uniformly to changes of time, and that when he "gets his range" all the fuses should give the same results.

Burning channels taken from the same lot that the ten fuses now sent to the proving ground, for trial with the shrapnel, were made from have been tested here and gave uniform results burned at rest. In graduating them I have made a correction of 20 per cent, to make the rate of burning agree with the expected rate of burning in flight, and it should agree nearly.

The time of flight to known points at Sandy Hook has been determined with great accuracy. If, then, this time is taken, say to the 2,000 yards target, and the fuse is set to this time, it should explode near the target, but it may be that it would not explode close enough to the desired point for observing and determining sufficiently the effect of the shrapnel.

As the shrapnel is expensive and there are but few of them, I respectfully recommend that one or more trial shots be made with the fuse in cheap shells, to "get the range," as has been explained above. When the correct setting for the fuse has been there determined, the fuses should thereafter explode the shrapnel near enough to the desired point.

I respectfully recommend what follows to the attention of the Department.

The artillerist does not guess at the distance and then turn to a table to find what time for his fuse and what elevation for his sight corresponds to his guessed distance. He learns by experience to guess at the time and elevation directly.

With the modern use of range finders, and the fact that most men would bring to artillery firing some ability already acquired in guessing at distance, and the probable fact that men can learn more quickly to guess accurately at distance than at time and elevation, I think that both our fuses and sights should be graduated to distance in yards, and not to time and degrees of elevation, and I respectfully recommend this.

What I have read (especially reports on the Franco-Prussian war) and observed, shows that the destruction of artillery at long ranges in battle has been insignificant compared with its possibilities, and that it is uniformly slight compared with the estimate of the officer who conducts the firing. He can not observe correctly in the smoke and on rough deceiving ground at long range, and frequently explodes shells at a harmless distance when he supposes he has his range. If a shell received from the enemy explodes within 200 feet of the point intended, it is remarkable enough to be talked about, and is probably more or less accidental. I believe that much of this inaccuracy has been due to the imperfection of time fuses, and I trust that in the fuse now on trial some advance has been made in the improvement of fuses.

I have made the French lead wire burning channel, and numerous tests of it here show a very uniform rate of burning. In the absence of knowledge of the French method of using this burning channel, I have devised a fuse for utilizing it here. Six of these fuses have been made and fired at Sandy Hook with satisfactory results.

It does not appear yet, however, that it possesses material advantages over the burning channel of the fuse now on trial, except that very important one that it should enable us to obtain a long time fuse without the necessity for resorting to objectionable slow burning compositions. These must give a large amount of objectionable (clogging) residuum in burning, and in the old horseshoe form of channel do not furnish room for proper course graduation. Also my experiments on several new slow-burning compositions (which were incorporated at the powder mill and thought to be improved in mode of manufacture) have not given satisfactory results.

If the maximum range for time-fuse firing for our field artillery can be limited to 3,000 yards, then we can use an excellent satisfactory quick burning composition in the present model fuse for field service only and could probably increase the size of the fuse for siege and seacoast service sufficiently to make room for 30 seconds burning of the French burning channel. I think, however, that a considerable number of the fuses with the French channel should be made and tried in various ways before recommending anything in the matter.

### FIRING RECORDS, PROVING GROUND, SANDY HOOK, N. J.

Preliminary trials were made November 21, 22, 1887. Nine samples (one marked A, five marked B, and three marked C) were fired into sand butt to be recovered. Fired from 3.2 inch B. L. rifle, steel, No. 6, West Point Foundry; charge, 3 pound; projectile, experimental shrapnel; lot, 1,777; weight, 13.4 pounds.

The following record of firings in test of this fuse are hereto appended:

August 20, 1888. Five fuses tested for time element.

September 14, 1888. Ten fuses tested for percussion element.

October 15 and 16, 1888. Ten fuses tested for percussion element, and six Hotchkiss base percussion fuses for comparison.

December 19, 1888. Six fuses tested for time element.

February 25, 1889. Twelve fuses tested for time element.

April 12, 13, 1889. Eleven fuses tested for time element.

June 11, 1889. Six time fuses to determine difference of the rate of burning in motion and at rest.

July 10, 12, 1889. Twenty rounds with fuse and twenty-one rounds with common shell weighted with lead and sand; also five rounds with experimental shrapnel. The breaking of projectiles in these firings detracts from their value as tests of the fuse.

November 1, 2, 1889. Twenty-five fuses tested for time and percussion.

April 24-28, 1890. Eleven fuses, pattern of April, 1890, tested. The pattern of April, 1890, which, illustrated in Plate 1, differs from former patterns in having a tongue "1" fitting into a groove in the fuse body and a somewhat smaller channel for the fuse composition.

*Record of firing in tests of Frankford Arsenal point com-*

[Object of firing, to test Frank-

| Date. | Cannon. | No. of fire. | Powder. Kind. | Powder. Weight. | Projectile. Kind. | Projectile. Weight. | Density of loading. | Travel of shot in bore. | Elevation. | Pressure per square inch of bore. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1888. | | | | *Lbs. Oz.* | | *Lbs. Oz.* | | *Inches.* | ° ″ | *Pounds.* |
| Aug. 20 | 3.2-inch B. L. rifle (steel), No. 3, modified, W. A. | 396 | Du Pont's I. K. F. Density, 1.725. | 3 8 | Service shell, lot 222. | [a]13 2 | 0.857 | 73.76 | 5 00 | 30,000 |
| Aug. 20 | | 397 | | 3 8 | | [a]13 2 | 0.857 | 73.76 | 4 00 | 30,500 |
| Aug. 20 | | 398 | | 3 8 | | [b]13 2 | 0.857 | 73.76 | 6 00 | .......... |
| Aug. 20 | | 399 | | 3 8 | | [c]13 2 | 0.857 | 73.76 | 7 30 | .......... |
| Aug. 20 | | 400 | | 3 8 | | [a]13 3 | 0.857 | 73.76 | 5 00 | .......... |

[Object of firing, to test percussion action

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1888. | 3.2-inch B. L. rifle (steel), No. 3, modified, W. A. | | | | | | | | | |
| Sept. 14 | | 411 | Du Pont's I. K. F. Density, 1.725. Granulation, 2,200. | 3 8 | Service shell. Lot 222.—Modified for Frankford Arsenal point combination fuse.[g] Lot 218. | [d]13 6 | ........ | ........ | 0 50 | .......... |
| Sept. 14 | | 412 | | 3 8 | | [e]13 6 | ........ | ........ | 0 50 | .......... |
| Sept. 14 | | 413 | | 3 8 | | [f]13 6 | ........ | ........ | 0 53 | .......... |
| Sept. 14 | | 414 | | 3 8 | | [a]13 6 | ........ | ........ | 1 00 | .......... |
| Sept. 14 | | 415 | | 3 8 | | [a]13 6 | ........ | ........ | 1 00 | .......... |
| Sept. 14 | P.M.—Barometer, 30.26; thermometer, 67; humidity, 31. | 416 | | 3 8 | | [a]13 6 | ........ | ........ | 1 02 | .......... |
| Sept. 14 | | 417 | | 3 8 | | [a]13 6 | ........ | ........ | 1 02 | .......... |
| Sept. 14 | | 418 | | 3 8 | | [a]13 6 | ........ | ........ | 1 05 | .......... |
| Sept. 14 | | 419 | | 3 8 | | [a]13 6 | ........ | ........ | 2 35 | .......... |
| Sept. 14 | | 420 | | 3 8 | | [a]13 6 | ........ | ........ | 2 35 | .......... |
| Sept. 14 | | 421 | | 3 8 | | [a]13 6 | ........ | ........ | 2 35 | .......... |
| Sept. 14 | | 422 | | 3 8 | | [a]13 6 | ........ | ........ | 2 35 | .......... |

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[a] Including 4 ounces K. L. powder, bursting charge.

[b] Including 6 ounces K. L. powder, bursting charge.

[c] Including 3 ounces K. L. powder, bursting charge.

[d] Including 6 ounces sand.

[e] Including 7 ounces sand.

[f] Including 4¼ ounces K. L. powder, bursting charge.

[g] In all the firings with the combination fuse the time igniter plunger was removed except in round 419. Fuse in this round set at 11¾ seconds.

*bination fuse, channel time train, at Sandy Hook, N. J.*

**ford Arsenal point time fuse.]**

| Recoil. | Wind, strength and direction. | Fuse set. | Time before bursting. | | Special remarks about each fire, such as effect on piece, action of breech, mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|---|---|
| *Ft. In.* | | *Secs.* | *Secs.* | | |
| | | | | | Gun mounted on Buffington field carriage No. 2. |
| ........ | Wind from right, 2 miles an hour. | 5 | 4½ | Fired to sea from field gun platform. Electric primers, model 1883. | |
| ........ | | 3 | 2½ | | |
| ........ | | 7 | 6½ | | |
| ........ | | 9 | 8½ | | |
| ........ | | 5 | ....... | | Shell broke up in or near gun.<br>P. M.—Barometer, 30.07; thermometer, 82; humidity, 47. |

**of Frankford Arsenal combination fuse.]**

| | | | | | |
|---|---|---|---|---|---|
| | | | | Gun mounted on Buffington field carriage No. 2. Electric primers, model 1883. | |
| 9 6 | Wind from front and left, 12 miles an hour. | ...... | ...... | Fired at screen 10 feet wide, by 20 feet high 120 yards in front of 1,000 yards target. | Struck 5 feet above ground. |
| 9 0 | | ...... | ...... | | Struck 2 feet above ground. |
| 9 6 | | ...... | ...... | | Struck lower edge of screen, and struck sand 10 yards beyond screen; burst on striking sand. |
| 9 0 | | ...... | ...... | | Struck screen 15 feet from ground and target 3 feet from ground. Did not burst. |
| 9 0 | | ...... | ...... | | Through screen 14 feet from ground, and through target 2½ feet from ground. Struck ground 12 yards beyond, ricochetted, and burst in air. |
| 9 6 | | ...... | ...... | | Through screen 14 feet from ground, and through target 2½ feet from ground; burst from passing through target or on striking ground afterwards near target. |
| 9 6 | | ...... | ...... | | Through screen 15 feet from ground, and through target 3 feet from ground; burst from passing through target or on striking ground afterwards near target. |
| 9 6 | | ...... | ...... | | Through screen 12 feet from ground. Struck 10 yards in front of target; burst, fragments passing through target. |
| 9 0 | | ...... | ...... | Fired at 1 mile target. | Did not burst. |
| 9 6 | | ...... | ...... | | Burst. Short sponge staff broken by dip of gun. |
| 9 0 | | ...... | ...... | | Struck target and burst. |
| 9 0 | | ...... | ...... | | Struck target; did not burst; clevis bolt of right brake broken through flaw. |
| | | | | In firing of Sept. 12, trail handspike split from socket to first strengthening band. | |

***Record of firing in tests of Frankford Arsenal point combination***

[Object of firing, to test Frankford

| Date. | Cannon. | No. of fire. | Powder. | | Projectile. | | Density of loading. | Travel of shot in bore. |
|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight | Kind. | Weight | | |
| | | | | *Lbs. Oz.* | | *Lbs. Oz.* | | *Inches.* |
| 1888. Oct. 15 | 3.2-inch B. L. rifle (steel), No. 3 modified, W. A.<br>P.M.—Barometer, 30.06; thermometer, 55; humidity, 44. | 429 | Du Pont's I. K. F. Density, 1.725. Granulation, 2,200. | 3 8 | Service shell, lot 194. | 13 6 | 0.857 | 73.76 |
| Oct. 15 | | 430 | | 3 8 | | 13 6 | 0.857 | 73.76 |
| Oct. 15 | | 431 | | 3 8 | Service shell, modified for Frankford Arsenal point combination fuse. Time igniter removed. | *13 6 | 0.857 | 73.76 |
| Oct. 15 | | 432 | | 3 8 | | *13 5 | 0.857 | 73.76 |
| Oct. 15 | | 433 | | 3 8 | | *13 4½ | 0.857 | 73.76 |
| Oct. 15 | | 434 | | 3 8 | | *13 5½ | 0.857 | 73.76 |
| Oct. 15 | | 435 | | 3 8 | | *13 5½ | 0.857 | 73.76 |
| Oct. 15 | | 436 | | 3 8 | | †13 1½ | ........ | 73.76 |
| Oct. 15 | | 437 | | 3 8 | | ‡13 1½ | ........ | 73.76 |
| Oct. 15 | | 438 | | 3 8 | | ‡13 6½ | ........ | 73.76 |
| Oct. 15 | | 439 | | 3 8 | | ‡13 5½ | 0.857 | 73.76 |

[Object of firing, to see if shell would explode from action

| Date. | Cannon. | No. of fire. | Powder. Kind. | Powder. Weight | Projectile. Kind. | Projectile. Weight | Density of loading. | Travel of shot in bore. |
|---|---|---|---|---|---|---|---|---|
| Oct. 16 | .............................. | 440 | Du Pont's I. K. F. Density, 1.725. Granulation, 2,200. | 3 8 | Service shell with Hotchkiss base percussion fuses. Lot 194. | ‡12 15½ | 0.857 | 73.76 |
| Oct. 16 | | 441 | | 3 8 | | ‡12 15 | 0.857 | 73.76 |
| Oct. 16 | | 442 | | 3 8 | | ‡12 14½ | 0.857 | 73.76 |
| Oct. 16 | | 443 | | 3 8 | | ‡12 15 | 0.857 | 73.76 |
| Oct. 16 | | 444 | | 3 8 | | ‡12 15 | 0.857 | 73.76 |
| Oct. 16 | | 445 | | 3 8 | | ‡13 1 | 0.857 | 73.76 |
| Oct. 16 | | 446 | | 3 8 | Service shell modified with Frankford Arsenal point combination fuse. Time plunger removed. Lot 222. | ‡13 4 | 0.857 | 73.76 |

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* Including 6 ounces K. L. powder, bursting charge.
† Including 1 ounce charcoal, 4½ ounces K. L. powder, bursting charge.
‡ Including 1 ounce charcoal, 4 ounces K. L. powder, bursting charge.

*fuse, channel time train, at Sandy Hook, N. J.*—Continued.

**Arsenal point fuse, acting by percussion.]**

| Elevation. | Wind, strength and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|
| ° ′ | | Gun mounted on Buffington field carriage No. 17. Rounds 429 and 430 sighting shots. Electric primers, model 1883. | |
| 1 2 | Wind from rear and right, 6 miles an hour. | Fired at screen 10 feet wide by 20 feet high, 120 yards in front of 1,000-yards target.<br>Before round 433 part of screen up to 7 feet from ground was removed and the part from 7 feet above ground up to 15 feet was made of double thickness, 1-inch boards; from 15 feet up it remained of single 1-inch boards. | Passed through screen. |
| 0 54 | | | Passed through screen 12 feet above ground and through target 2½ feet above ground. |
| 0 56 | | | Passed through screen 9 feet above ground. Burst on striking ground 42 feet in front of target; 14 pieces went through target. |
| 0 58 | | | Passed through screen 3½ feet above ground. Burst on striking ground 42 feet in rear of shield; 13 pieces went through target. |
| 0 58 | | | Passed through screen 15¼ feet above ground (single thickness of board), and through target. Burst before striking ground. |
| 0 53 | | | Passed under screen. Burst 105 feet in rear of screen on striking ground; 17 pieces went through target. |
| 0 54 | | | Passed through screen 8 feet 8 inches from ground. Burst on striking ground. |
| 0 53 | | | Passed through screen 11 feet from ground. Burst after passing through screen. |
| 0 52 | | | Passed through screen 8 feet 9 inches from ground. Burst immediately after passing through screen. |
| 0 52 | | | Passed through screen 9 feet from ground. Burst before striking ground in rear of screen. |
| 0 53 | | | Passed through screen 10 feet from ground. Struck ground 16 feet in front of target and burst on striking ground. |

**of percussion fuse on passing through two 1-inch boards.]**

| | | | |
|---|---|---|---|
| 0 54 | Wind from right, 5 miles an hour. | Fired at screen 880 yards from, and target 1,000 yards from gun.<br>The lower edge of screen was 7 feet above ground, and it was of double thickness, 1-inch boards, up to 15 feet from ground; above this of single thickness, 1-inch boards. | Struck screen 8 feet from ground. Burst on passing through screen. |
| 0 56 | | | Struck screen 11½ feet from ground. Burst on passing through screen. |
| 0 56 | | | Struck screen 11 feet from ground. Burst on passing through screen. |
| 1 00 | | | Struck screen 14½ feet from ground and target. Burst on passing through target. |
| 0 52 | | Fired to strike ground about 1,000 yards from gun. | Burst on striking sand. |
| 0 54 | | Fired to strike water about 1,000 yards from gun. | Did not burst. |
| ...... | | Fired to strike water about 1,000 yards from gun. | Burst on striking water. |
| | | Electric primers, model 1883. | P. M.—Barometer, 30.02; thermometer, 59; humidity, 42. |

*Record of firing with 3.2-inch B. L. rifle (steel), No. 18, West Point Foundry,*

[Object of firing, to test Frankford Arsenal

| Date. | Cannon. | No. of fire. | Powder. |  | Projectile. |  | Elevation. | Wind, strength and direction. |
|---|---|---|---|---|---|---|---|---|
|  |  |  | Kind. | Weight | Kind. | Weight |  |  |
|  |  |  |  | *Lbs. Oz.* |  | *Lbs. Oz.* | ° |  |
| 1888. Dec. 19 | 3.2-inch B. L. rifle (steel), No. 18, W. P. F. | 295 | Du Pont's I. K. F. Density, 1.725. Granulation, 2, 200. | 3 12 | Service shell (lot 222) altered to receive Frankford Arsenal point combination fuse; ⅛-inch copper band hammered in. | *13 3 | 10 | Wind from rear, 20 miles an hour. |
| Dec. 19 |  | 296 |  | 3 12 |  | *13 1½ | 10 |  |
| Dec. 19 |  | 297 |  | 3 12 |  | *13 1 | 10 |  |
| Dec. 19 |  | 298 |  | 3 12 |  | *13 2 | 10 |  |
| Dec. 19 |  | 299 |  | 3 12 |  | *13 3 | 10 |  |
| Dec. 19 |  | 300 |  | 3 12 |  | *13 0 | 10 |  |

*Including 5½ ounces K. L. powder, bursting charge, and ½ ounce charcoal.

| Date. | Cannon. | No. of fire. | Powder. |  | Projectile. |  | Elevation. | Instrumental velocity. | Computed time of flight. | Recoil. |
|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  | Kind. | Weight | Kind. | Weight |  |  |  |  |
|  | 3.2-inch B.L. rifle (steel), No. 18, W. P. F. |  |  | *Lbs. Oz.* |  | *Lbs. Oz.* | ° ′ |  | *Secs.* | *Ft. In.* |
| 1889. Feb. 25 | P.M.—Barometer, 30.68; thermometer, 22; humidity, 58. | 314 | Du Pont's I. K. F. Density, 1.725. Granulation, 2,200. | 3 12 | Service shell altered to receive Frankford Arsenal point combination fuse; ⅛ inch copper band hammered in. Lot 232. Percussion plunger removed. | *13 6 | 0 55 | Instrumental velocity at 100 feet from muzzle, 1,602 feet; muzzle velocity, 1,620 feet. Mean of 3 shots on February 23, 1889. | 1.70 | 8 6 |
| Feb. 25 |  | 315 |  | 3 12 |  | †13 6 | 0 55 |  | ...... | 9 0 |
| Feb. 25 |  | 316 |  | 3 12 |  | *13 5 | 0 57 |  | 2.24 | 9 0 |
| Feb. 25 |  | 317 |  | 3 12 |  | †13 5 | 0 57 |  | ...... | 9 0 |
| Feb. 25 |  | 318 |  | 3 12 |  | *13 5 | 0 57 |  | 2.32 | 10 6 |
| Feb. 25 |  | 319 |  | 3 12 |  | †13 6 | 0 57 |  | ...... | 9 3 |
| Feb. 25 |  | 320 |  | 3 12 |  | *13 5 | 0 57 |  | 2.73 | 10 6 |
| Feb. 25 |  | 321 |  | 3 12 |  | †13 6 | ...... |  | ...... | 10 6 |
| Feb. 25 |  | 322 |  | 3 12 |  | †13 6 | 0 57 |  | ...... | 10 0 |
| Feb. 25 |  | 323 |  | 3 12 |  | *13 6 | 2 38 |  | ...... | 11 0 |
| Feb. 25 |  | 324 |  | 3 12 |  | *13 5 | 2 45 |  | 4.95 | 9 6 |
| Feb. 25 |  | 325 |  | 3 12 |  | *13 5 | 2 45 |  | 4.66 | 9 6 |

*Including 5 ounces K. L. powder, bursting charge.
†Including 6 ounces K. L. powder, bursting charge.

*at Sandy Hook, N. J., from December 19, 1888, to February 25, 1889.*

**point combination fuse for time.]**

| Fuse set at— | First watch, burst in— | Second watch, burst in— | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|---|
| | | | Gun mounted on Buffington field carriage No. 17 with old spring brakes. Freyre gas-checks. Electric primers, model 1883. | |
| *Secs.*<br>3 | *Secs.*†<br>2⅞ | *Secs.*‡<br>3 | Fired from field-gun platform to sea. | P. M.—Barometer, 29.96; thermometer, 30; humidity, 56. |
| 3 | 1⅞ | 1⅝ | | |
| 3 | Lost. | 1⅞ | | |
| 6 | 4⅞ | Lost. | | |
| 6 | 5 | 4⅞ | | |
| 6 | 4½ | 4½ | | |

†Observer. Lieut. Gibson. ‡ Observer, Capt. Greer.

| Wind, strength and direction. | Fuse set at— | Burst, in seconds (first stop watch)‡ | Burst, in seconds (second stop watch)§ | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|---|---|
| | | | | Cartridges put up December 6, 1888, and stored in service magazine. Gun mounted on Buffington steel field carriage, No. 17. Old spring brakes. Freyre gas-check throughout. Friction primers, long. | |
| Wind from rear and left, 16 miles an hour. | *Secs.*<br>2½ | Lost. | 2½ | Fired from field-gun platform at 1,000-yards target. | Fuse with brass band; burst 200 yards in front of target. |
| | 2½ | Lost. | 1½ | | Fuse with lead band; burst 300 yards in front of target. |
| | 3 | 2⅞ | 2¾ | | Fuse with brass band; burst 50 feet beyond target. |
| | 3 | 2½ | 2½ | | Fuse with lead band; burst 90 yards in front of target. |
| | 3 | 2⅞ | 3 | | Fuse with brass band; burst 50 yards beyond target. |
| | 3 | 2⅞ | 2½ | | Fuse with lead band; burst 100 yards in front of target. |
| | 3½ | 3½ | 3½ | | Fuse with bras, band; burst 200 yards in front of target. |
| | 3½ | 2⅞ | Lost. | | Fuse with lead band; burst 175 yards in front of target. |
| | 4½ | 3½ | 4 | | Fuse with lead band; burst 350 yards beyond target. |
| | 5 | ........ | ........ | Fired from field-gun platform at 1-mile target. | Fuse with brass band; did not burst. |
| | 5 | 5⅞ | 5½ | | Fuse with brass band; burst 200 yards beyond target. |
| | 5 | 5⅞ | 4⅞ | | Fuse with brass band; burst 100 yards beyond target. |
| | | | | Firing conducted by the proof officer.<br>Lieut. Col. D. W. Flagler, Ordnance Department, U. S. Army, present. | |

‡ Capt. Greer. § Lieut. Gibson.

*Record of firing with 3.2-inch B. L. rifle (steel), No. 18, West Point*

[Object of firing, to test Frankford Arsenal

| Date. | Cannon. | No. of fire. | Powder. Kind. | Powder. Weight. | Projectile. Kind. | Projectile. Weight. | Projectile. Weight. | Elevation. | Recoil. | Wind, strength and direction. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1889. | 3.2 inch B. L. rifle (steel), No 18, W. P. F. | | | *Lbs. Oz.* | | | *Lbs. Oz.* | ° ′ | *Ft. In.* | |
| Apr. 12 | P. M.—Barometer, 29.65; thermometer, 65; humidity, 63. | 530 | Du Pont's I. K. F. Density, 1.725. Granulation, 2,200. | 3 12 | Service shell altered to receive Frankford Arsenal point combination fuse. Percussion plunger removed. | Lot 236. | *13 4 | 2 55 | 12 6 | Wind from the right, 24 miles an hour. |
| Apr. 12 | | 531 | | 3 12 | | | *13 4 | 3 00 | 12 0 | |
| Apr. 12 | | 532 | | 3 12 | | | *13 4 | 3 00 | 12 0 | |
| Apr. 12 | | 533 | | 3 12 | | | *13 4 | 3 00 | 12 0 | |
| Apr. 12 | | 534 | | 3 12 | | | *13 3½ | 3 00 | 12 0 | |
| Apr. 13 | A. M.—Barometer, 29.81; thermometer, 48; humidity, 68. | 535 | | 3 12 | | Lot 237. | †13 1½ | 3 00 | 16 0 | Wind from the right, 2 miles an hour. |
| Apr. 13 | | 536 | | 3 12 | | | *13 3 | 3 30 | 13 0 | |
| Apr. 13 | | 537 | | 3 12 | | | *13 6 | 3 30 | 13 0 | |
| Apr. 13 | | 538 | | 3 12 | | | *13 6 | 3 30 | 13 0 | |
| Apr. 13 | | 539 | | 3 12 | | | *13 4 | 3 30 | ........ | |
| Apr. 13 | | 540 | | 3 12 | | | †12 14 | 3 30 | ........ | |

* Including 5 ounces K. L. powder, bursting charge.
† Including 3 ounces K. L. powder, bursting charge.

[Object of firing, to test time fuses furnished by Lieut. Col. D. W. Flagler, Ordnance

| Date. | Cannon. | No. of fire. | Powder. Kind. | Powder. Weight | Projectile. Kind. | Projectile. Weight | Density of loading. | Travel of shot in bore. | Elevation. | Wind, strength and direction. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1889. | 3.2-inch B. L. rifle (steel), No. 18, W. P. F. | | | *Lbs. Oz.* | | *Lbs. Oz.* | | *Inches.* | ° ′ | |
| June 11 | A. M.—Barometer, 30.17; thermometer, 73; humidity, 84. | 715 | Du Pont's I. K. F. Density, 1.725. Granulation, 2,200. | 3 12 | Service shell altered to receive Frankford Arsenal point time fuse. | *13 7½ | 0.827 | 73.76 | 3 30 | Wind from the front, 5 miles an hour. |
| June 11 | | 716 | | 3 12 | | †13 7½ | 0.827 | 73.76 | 3 00 | |
| June 11 | | 717 | | 3 12 | | ‡13 7½ | 0.827 | 73.76 | 3 00 | |
| June 11 | | 718 | | 3 12 | | *13 7½ | 0.827 | 73.76 | 3 00 | |
| June 11 | | 719 | | 3 12 | | §13 7½ | 0.827 | 73.76 | 3 00 | |
| June 11 | | 720 | | 3 12 | | ‖13 7½ | 0.827 | 73.76 | 3 00 | |

* Including 3 ounces K. L. powder, bursting charge.
† Including 6 ounces K. L. powder, bursting charge.
‡ Including 4½ ounces lead, 6 ounces K. L. powder, bursting charge.
§ Including 4½ ounces K. L. powder, bursting charge.
‖ Including 3 ounces K. L. powder.

*Foundry, at Sandy Hook, N. J., from April 12 to June 11, 1889.*

**point combination fuse for time.]**

| Fuse set at— | Burst in— | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc. and metrological data. | Calculated time. |
|---|---|---|---|---|
| *Secs.* | *Secs.*‡ | Gun mounted on Buffington light steel field carriage No. 1. Bow-spring brakes. Freyre gas-check. | | |
| 5⅛ | 4⅜ | | Burst 100 yards beyond 1-mile target. Not reliable. | ............ |
| 5⅜ | 4¼ | | Burst near 1 mile target. Not reliable. | ............ |
| 6⅛ | ........ | | Burst about 50 yards from muzzle. Not reliable. | ............ |
| 6⅛ | 5 | Fired from field-gun platform to burst beyond 1-mile target. Distance determined by men placed at intervals of 100 feet opposite poles set near the line of fire at the same intervals. | Burst 5,950 feet from gun....... | 5.04 |
| 6⅛ | 5⅛ | | Burst 5,925 feet from gun....... | 5.02 |
| 7 | ........ | | Trial shot. Did not burst...... | ............ |
| 6⅜ | 5⅜ | | Burst 6,350 feet from gun ...... | 5.43 |
| 6⅝ | 5¼ | | Burst 6,325 feet from gun ...... | 5.43 |
| 6⅝ | Lost. | | Range lost. No explosion observed. | ............ |
| 6⅝ | 5¼ | | Burst 6,320 feet from gun ...... | 5.43 |
| 6⅝ | 5¼ | | Burst at 6,225 feet from gun.... | 5.32 |
| | | Firing conducted by Capt. J. C. Ayres, Ordnance Department.<br>Lieut. Col. D. W. Flagler, Ordnance Department, present. | | |

‡ Timed by Lieut. W. W. Gibson with a flight timer.

**Department, and to determine difference of the rate of burning in motion and at rest.]**

| Fuse set at— | Burst in— | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments etc., and metrological data. |
|---|---|---|---|
| *Secs.* | *Secs.* | | |
| 6 | 4⅜ | Gun mounted on Buffington steel field carriage No. 1, with old spiral-spring brakes. Freyre gas-check. Fuses cut to burn 6 seconds when shell is at rest. Fired from field-gun platforms. Aimed at left corner of 1-mile target. Telephone would not work and firing was conducted by signaling party at target with flags. Friction primers, long. The heavy growth of underbrush in the vicinity of the 1-mile target made it difficult to observe the place of bursting accurately. Calculated time of flight to moment of explosion: For 1 mile, 4.35 seconds; for 5,654 feet, 4.54 seconds. Time taken with a split-second watch by Capt. J. C. Ayres and verified by Lieut. Col. Flagler with another, except in round 715, when he did not catch the explosion. Observations by Lieut. W. W. Gibson, O. D., and men along the range. | No burst observed. |
| 6 | 4¼ | | Burst near 1-mile target. Exact range not ascertained. Piece struck on 2,000 yards bombproof. |
| 6 | 4⅜ | | Burst at 1 mile, approximately. |
| 6 | 4⅝ | | Burst at 5,654 feet. |
| 6 | ........ | | Failed to burst. |
| 6 | 4¼ | | Burst at 5,200 feet approximately. |
| | | Firing conducted by Capt. J. C. Ayres, O. D.<br>Present, Lieut. Col. D. W. Flagler, O. D. | |

***Record of firing in tests of Frankford Arsenal point com-***

[Object of firing, to test Frank-

| Date. | Cannon. | No. of fire. | Powder. |  | Projectile. |  | Density of loading. | Travel of shot in bore. | Elevation. | Pressure per square inch of bore. |
|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  | Kind. | Weight. | Kind. | Weight. |  |  |  |  |
| 1888. |  |  |  | *Lbs. Oz.* |  | *Lbs. Oz.* |  | *Inches.* | ° ″ | *Pounds.* |
| Aug. 20 | 3.2-inch B. L. rifle (steel), No. 3, modified, W. A. | 396 | Du Pont's I. K. F. Density, 1.725. | 3 8 | Service shell, lot 222. | [a]13 2 | 0.857 | 73.76 | 5 00 | 30,000 |
| Aug. 20 |  | 397 |  | 3 8 |  | [a]13 2 | 0.857 | 73.76 | 4 00 | 30,500 |
| Aug. 20 |  | 398 |  | 3 8 |  | [b]13 2 | 0.857 | 73.76 | 6 00 | .......... |
| Aug. 20 |  | 399 |  | 3 8 |  | [c]13 2 | 0.857 | 73.76 | 7 30 | .......... |
| Aug. 20 |  | 400 |  | 3 8 |  | [a]13 3 | 0.857 | 73.76 | 5 00 | .......... |

[Object of firing, to test percussion action

| Date. | Cannon. | No. of fire. | Powder kind. | Powder weight. | Projectile kind. | Projectile weight. | Density of loading. | Travel of shot in bore. | Elevation. | Pressure per square inch of bore. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1888. | 3.2-inch B. L. rifle (steel), No. 3, modified, W. A. |  |  |  |  |  |  |  |  |  |
| Sept. 14 |  | 411 | Du Pont's I. K. F. Density, 1.725. Granulation, 2,200. | 3 8 | Service shell.<br>Lot 222.—Modified for Frankford Arsenal point combination fuse.[g]<br>Lot 218. | [d]13 6 | ........ | ........ | 0 50 | .......... |
| Sept. 14 |  | 412 |  | 3 8 |  | [e]13 6 | ........ | ........ | 0 50 | .......... |
| Sept. 14 |  | 413 |  | 3 8 |  | [f]13 6 | ........ | ........ | 0 53 | .......... |
| Sept. 14 |  | 414 |  | 3 8 |  | [a]13 6 | ........ | ........ | 1 00 | .......... |
| Sept. 14 |  | 415 |  | 3 8 |  | [a]13 6 | ........ | ........ | 1 00 | .......... |
| Sept. 14 | P.M.—Barometer, 30.26; thermometer, 67; humidity, 31. | 416 |  | 3 8 |  | [a]13 6 | ........ | ........ | 1 02 | .......... |
| Sept. 14 |  | 417 |  | 3 8 |  | [a]13 6 | ........ | ........ | 1 02 | .......... |
| Sept. 14 |  | 418 |  | 3 8 |  | [a]13 6 | ........ | ........ | 1 05 | .......... |
| Sept. 14 |  | 419 |  | 3 8 |  | [a]13 6 | ........ | ........ | 2 35 | .......... |
| Sept. 14 |  | 420 |  | 3 8 |  | [a]13 6 | ........ | ........ | 2 35 | .......... |
| Sept. 14 |  | 421 |  | 3 8 |  | [a]13 6 | ........ | ........ | 2 35 | .......... |
| Sept. 14 |  | 422 |  | 3 8 |  | [a]13 6 | ........ | ........ | 2 35 | .......... |

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[a] Including 4 ounces K. L. powder, bursting charge.
[b] Including 6 ounces K. L. powder, bursting charge.
[c] Including 3 ounces K. L. powder, bursting charge.
[d] Including 6 ounces sand.
[e] Including 7 ounces sand.
[f] Including 4¼ ounces K. L. powder, bursting charge.
[g] In all the firings with the combination fuse the time igniter plunger was removed except in round 419. Fuse in this round set at 11½ seconds.

*bination fuse, channel time train, at Sandy Hook, N. J.*

**ford Arsenal point time fuse.]**

| Recoil. | Wind, strength and direction. | Fuse set. | Time before bursting. | | Special remarks about each fire, such as effect on piece, action of breech, mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|---|---|
| *Ft. In.* | | *Secs.* | *Secs.* | | |
| | | | | | Gun mounted on Buffington field carriage No. 2. |
| ........ | Wind from right, 2 miles an hour. | 5 | 4½ | Fired to sea from field gun platform. Electric primers, model 1883. | |
| ........ | | 3 | 2¾ | | |
| ........ | | 7 | 6¾ | | |
| ........ | | 9 | 8¼ | | |
| ........ | | 5 | ....... | | Shell broke up in or near gun.<br>P. M.—Barometer, 30.07; thermometer, 82; humidity, 47. |

**of Frankford Arsenal combination fuse.]**

| | | | | | |
|---|---|---|---|---|---|
| | | | | Gun mounted on Buffington field carriage No. 2. Electric primers, model 1883. | |
| 9 6 | Wind from front and left, 12 miles an hour. | ...... | ....... | Fired at screen 10 feet wide, by 20 feet high 120 yards in front of 1,000 yards target. | Struck 5 feet above ground. |
| 9 0 | | | | | Struck 2 feet above ground. |
| 9 6 | | ...... | ....... | | Struck lower edge of screen, and struck sand 10 yards beyond screen; burst on striking sand. |
| 9 0 | | ...... | ....... | | Struck screen 15 feet from ground and target 3 feet from ground. Did not burst. |
| 9 0 | | ...... | ....... | | Through screen 14 feet from ground, and through target 2½ feet from ground. Struck ground 12 yards beyond, ricochetted, and burst in air. |
| 9 6 | | ...... | ....... | | Through screen 14 feet from ground, and through target 2½ feet from ground; burst from passing through target or on striking ground afterwards near target. |
| 9 6 | | ...... | ....... | | Through screen 15 feet from ground, and through target 3 feet from ground; burst from passing through target or on striking ground afterwards near target. |
| 9 6 | | ...... | ....... | | Through screen 12 feet from ground. Struck 10 yards in front of target; burst, fragments passing through target. |
| 9 0 | | ...... | ....... | Fired at 1 mile target. | Did not burst. |
| 9 6 | | ...... | ....... | | Burst. Short sponge staff broken by dip of gun. |
| 9 0 | | ...... | ....... | | Struck target and burst. |
| 9 0 | | ...... | ....... | | Struck target; did not burst; clevis bolt of right brake broken through flaw. |
| | | | | In firing of Sept. 12, trail handspike split from socket to first strengthening band. | |

*Record of firing in tests of Frankford Arsenal point combination*

[Object of firing, to test Frankford

| Date. | Cannon. | No. of fire. | Powder. |  | Projectile. |  | Density of loading. | Travel of shot in bore. |
|---|---|---|---|---|---|---|---|---|
|  |  |  | Kind. | Weight | Kind. | Weight |  |  |
|  |  |  |  | *Lbs. Oz.* |  | *Lbs. Oz.* |  | *Inches.* |
| 1888. | 3.2-inch B. L. rifle (steel), No. 3 modified, W. A. |  |  |  |  |  |  |  |
| Oct. 15 |  | 429 | Du Pont's I. K. F. Density, 1.725. Granulation, 2,200. | 3 8 | Service shell, lot 194. | 13 6 | 0.857 | 73.76 |
| Oct. 15 |  | 430 |  | 3 8 |  | 13 6 | 0.857 | 73.76 |
| Oct. 15 |  | 431 |  | 3 8 | Service shell, modified for Frankford Arsenal point combination fuse. Time igniter removed. | *13 6 | 0.857 | 73.76 |
| Oct. 15 |  | 432 |  | 3 8 |  | *13 5 | 0.857 | 73.76 |
| Oct. 15 |  | 433 |  | 3 8 |  | *13 4½ | 0.857 | 73.76 |
| Oct. 15 | P.M.—Barometer, 30.06; thermometer, 55; humidity, 44. | 434 |  | 3 8 |  | *13 5½ | 0.857 | 73.76 |
| Oct. 15 |  | 435 |  | 3 8 |  | *13 5½ | 0.857 | 73.76 |
| Oct. 15 |  | 436 |  | 3 8 |  | †13 1½ | ........ | 73.76 |
| Oct. 15 |  | 437 |  | 3 8 |  | ‡13 1½ | ........ | 73.76 |
| Oct. 15 |  | 438 |  | 3 8 |  | ‡13 6½ | ........ | 73.76 |
| Oct. 15 |  | 439 |  | 3 8 |  | ‡13 5½ | 0.857 | 73.76 |

[Object of firing, to see if shell would explode from action

| Date. | Cannon. | No. of fire. | Powder kind. | Powder weight. | Projectile kind. | Projectile weight. | Density of loading. | Travel of shot in bore. |
|---|---|---|---|---|---|---|---|---|
| Oct. 16 | ........................................ | 440 | Du Pont's I. K. F. Density, 1.725. Granulation, 2,200. | 3 8 | Service shell with Hotchkiss base percussion fuses. Lot 194. | ‡12 15½ | 0.857 | 73.76 |
| Oct. 16 |  | 441 |  | 3 8 |  | ‡12 15 | 0.857 | 73.76 |
| Oct. 16 |  | 442 |  | 3 8 |  | ‡12 14½ | 0.857 | 73.76 |
| Oct. 16 |  | 443 |  | 3 8 |  | ‡12 15 | 0.857 | 73.76 |
| Oct. 16 |  | 444 |  | 3 8 |  | ‡12 15 | 0.857 | 73.76 |
| Oct. 16 |  | 445 |  | 3 8 |  | ‡13 1 | 0.857 | 73.76 |
| Oct. 16 |  | 446 |  | 3 8 | Service shell modified with Frankford Arsenal point combination fuse. Time plunger removed. Lot 222. | ‡13 4 | 0.857 | 73.76 |

* Including 6 ounces K. L. powder, bursting charge.
† Including 1 ounce charcoal, 4½ ounces K. L. powder, bursting charge.
‡ Including 1 ounce charcoal, 4 ounces K. L. powder, bursting charge.

*fuse, channel time train, at Sandy Hook, N. J.*—Continued.

**Arsenal point fuse, acting by percussion.]**

| Elevation.<br>° ′ | Wind, strength and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|
| 1 2 | Wind from rear and right, 6 miles an hour. | Gun mounted on Buffington field carriage No. 17. Rounds 429 and 430 sighting shots. Electric primers, model 1883.<br>Fired at screen 10 feet wide by 20 feet high, 120 yards in front of 1,000-yards target.<br>Before round 433 part of screen up to 7 feet from ground was removed and the part from 7 feet above ground up to 15 feet was made of double thickness, 1-inch boards; from 15 feet up it remained of single 1-inch boards. | Passed through screen. |
| 0 54 | | | Passed through screen 12 feet above ground and through target 2½ feet above ground. |
| 0 56 | | | Passed through screen 9 feet above ground. Burst on striking ground 42 feet in front of target; 14 pieces went through target. |
| 0 58 | | | Passed through screen 3½ feet above ground. Burst on striking ground 42 feet in rear of shield; 13 pieces went through target. |
| 0 58 | | | Passed through screen 15½ feet above ground (single thickness of board), and through target. Burst before striking ground. |
| 0 53 | | | Passed under screen. Burst 105 feet in rear of screen on striking ground; 17 pieces went through target. |
| 0 54 | | | Passed through screen 8 feet 8 inches from ground. Burst on striking ground. |
| 0 53 | | | Passed through screen 11 feet from ground. Burst after passing through screen. |
| 0 52 | | | Passed through screen 8 feet 9 inches from ground. Burst immediately after passing through screen. |
| 0 52 | | | Passed through screen 9 feet from ground. Burst before striking ground in rear of screen. |
| 0 53 | | | Passed through screen 10 feet from ground. Struck ground 16 feet in front of target and burst on striking ground. |

**of percussion fuse on passing through two 1-inch boards.]**

| | | | |
|---|---|---|---|
| 0 54 | Wind from right, 5 miles an hour. | Fired at screen 880 yards from, and target 1,000 yards from gun.<br>The lower edge of screen was 7 feet above ground, and it was of double thickness, 1-inch boards, up to 15 feet from ground; above this of single thickness, 1-inch boards. | Struck screen 8 feet from ground. Burst on passing through screen. |
| 0 56 | | | Struck screen 11½ feet from ground. Burst on passing through screen. |
| 0 56 | | | Struck screen 11 feet from ground. Burst on passing through screen. |
| 1 00 | | | Struck screen 14½ feet from ground and target. Burst on passing through target. |
| 0 53 | | Fired to strike ground about 1,000 yards from gun. | Burst on striking sand. |
| 0 54 | | Fired to strike water about 1,000 yards from gun. | Did not burst. |
| ...... | | Fired to strike water about 1,000 yards from gun.<br>Electric primers, model 1883. | Burst on striking water.<br>P. M.—Barometer, 30.02; thermometer, 59; humidity, 42. |

*Record of firing with 3.2-inch B. L. rifle (steel), No. 18, West Point Foundry,*

[Object of firing, to test Frankford Arsenal

| Date. | Cannon. | No. of fire. | Powder. |  | Projectile. |  | Elevation. | Wind, strength and direction. |
|---|---|---|---|---|---|---|---|---|
|  |  |  | Kind. | Weight | Kind. | Weight |  |  |
| 1888. |  |  |  | *Lbs. Oz.* |  | *Lbs. Oz.* | ° |  |
| Dec. 19 | 3.2-inch B. L. rifle (steel), No. 18, W. P. F. | 295 | Du Pont's I. K. F. Density, 1.725. Granulation, 2,200. | 3 12 | Service shell (lot 222) altered to receive Frankford Arsenal point combination fuse; ⅛-inch copper band hammered in. | *13 3 | 10 | Wind from rear, 20 miles an hour. |
| Dec. 19 |  | 296 |  | 3 12 |  | *13 1½ | 10 |  |
| Dec. 19 |  | 297 |  | 3 12 |  | *13 1 | 10 |  |
| Dec. 19 |  | 298 |  | 3 12 |  | *13 2 | 10 |  |
| Dec. 19 |  | 299 |  | 3 12 |  | *13 3 | 10 |  |
| Dec. 19 |  | 300 |  | 3 12 |  | *13 0 | 10 |  |

*Including 5½ ounces K. L. powder, bursting charge, and ½ ounce charcoal.

| Date. | Cannon. | No. of fire. | Powder. |  | Projectile. |  | Elevation. | Instrumental velocity. | Computed time of flight. | Recoil. |
|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  | Kind. | Weight | Kind. | Weight |  |  |  |  |
|  | 3.2-inch B.L. rifle (steel), No. 18, W. P. F. |  |  |  |  |  |  |  |  |  |
| 1889. |  |  |  | *Lbs. Oz.* |  | *Lbs. Oz.* | ° ′ |  | *Secs.* | *Ft. In.* |
| Feb. 25 | P.M.—Barometer, 30.68; thermometer, 22; humidity, 58. | 314 | Du Pont's I. K. F. Density, 1.725. Granulation, 2,200. | 3 12 | Service shell altered to receive Frankford Arsenal point combination fuse; ⅛ inch copper band hammered in. Lot 232. Percussion plunger removed. | *13 6 | 0 55 | Instrumental velocity at 100 feet from muzzle, 1,602 feet; muzzle velocity, 1,620 feet. Mean of 3 shots on February 28, 1889. | 1.70 | 8 6 |
| Feb. 25 |  | 315 |  | 3 12 |  | †13 6 | 0 55 |  | ...... | 9 0 |
| Feb. 25 |  | 316 |  | 3 12 |  | *13 5 | 0 57 |  | 2.24 | 9 0 |
| Feb. 25 |  | 317 |  | 3 12 |  | †13 5 | 0 57 |  | ...... | 9 0 |
| Feb. 25 |  | 318 |  | 3 12 |  | *13 5 | 0 57 |  | 2.32 | 10 6 |
| Feb. 25 |  | 319 |  | 3 12 |  | †13 6 | 0 57 |  | ...... | 9 3 |
| Feb. 25 |  | 320 |  | 3 12 |  | *13 5 | 0 57 |  | 2.73 | 10 6 |
| Feb. 25 |  | 321 |  | 3 12 |  | †13 6 | ...... |  | ...... | 10 6 |
| Feb. 25 |  | 322 |  | 3 12 |  | †13 6 | 0 57 |  | ...... | 10 0 |
| Feb. 25 |  | 323 |  | 3 12 |  | *13 6 | 2 38 |  | ...... | 11 0 |
| Feb. 25 |  | 324 |  | 3 12 |  | *13 5 | 2 45 |  | 4.95 | 9 6 |
| Feb. 25 |  | 325 |  | 3 12 |  | *13 5 | 2 45 |  | 4.66 | 9 6 |

*Including 5 ounces K. L. powder, bursting charge.
†Including 6 ounces K. L. powder, bursting charge.

*at Sandy Hook, N. J., from December 19, 1888, to February 25, 1889.*

**point combination fuse for time.]**

| Fuse set at— | First watch, burst in— | Second watch, burst in— | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|---|
| | | | Gun mounted on Buffington field carriage No. 17 with old spring brakes. Freyre gas-checks. Electric primers, model 1883. | |
| *Secs.*<br>3 | *Secs.*†<br>2⅘ | *Secs.*‡<br>3 | Fired from field-gun platform to sea. | P. M.—Barometer, 29.96; thermometer, 30; humidity, 56. |
| 3 | 1⅗ | 1⅘ | | |
| 3 | Lost. | 1⅗ | | |
| 6 | 4⅗ | Lost. | | |
| 6 | 5 | 4⅗ | | |
| 6 | 4⅘ | 4⅘ | | |

†Observer, Lieut. Gibson. ‡Observer, Capt. Greer.

| Wind, strength and direction. | Fuse set at— | Burst, in seconds (first stop watch)‡ | Burst, in seconds (second stop watch)§ | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|---|---|
| | | | | Cartridges put up December 6, 1888, and stored in service magazine. Gun mounted on Buffington steel field carriage, No. 17. Old spring brakes. Freyre gas-check throughout. Friction primers, long. | |
| Wind from rear and left, 16 miles an hour. | *Secs.*<br>2¼ | Lost. | 2⅕ | Fired from field-gun platform at 1,000-yards target. | Fuse with brass band; burst 200 yards in front of target. |
| | 2¼ | Lost. | 1⅘ | | Fuse with lead band; burst 300 yards in front of target. |
| | 3 | 2⅘ | 2⅘ | | Fuse with brass band; burst 50 feet beyond target. |
| | 3 | 2⅕ | 2⅘ | | Fuse with lead band; burst 90 yards in front of target. |
| | 3 | 2⅗ | 3 | | Fuse with brass band; burst 50 yards beyond target. |
| | 3 | 2⅖ | 2⅗ | | Fuse with lead band; burst 100 yards in front of target. |
| | 3¼ | 3⅕ | 3⅕ | | Fuse with brass band; burst 200 yards in front of target. |
| | 3¼ | 2⅖ | Lost. | | Fuse with lead band; burst 175 yards in front of target. |
| | 4¼ | 3⅘ | 4 | | Fuse with lead band; burst 350 yards beyond target. |
| | 5 | ........ | ........ | Fired from field-gun platform at 1-mile target. | Fuse with brass band; did not burst. |
| | 5 | 5⅖ | 5⅕ | | Fuse with brass band; burst 200 yards beyond target. |
| | 5 | 5⅖ | 4⅘ | | Fuse with brass band; burst 100 yards beyond target. |
| | | | | Firing conducted by the proof officer.<br>Lieut. Col. D. W. Flagler, Ordnance Department, U. S. Army, present. | |

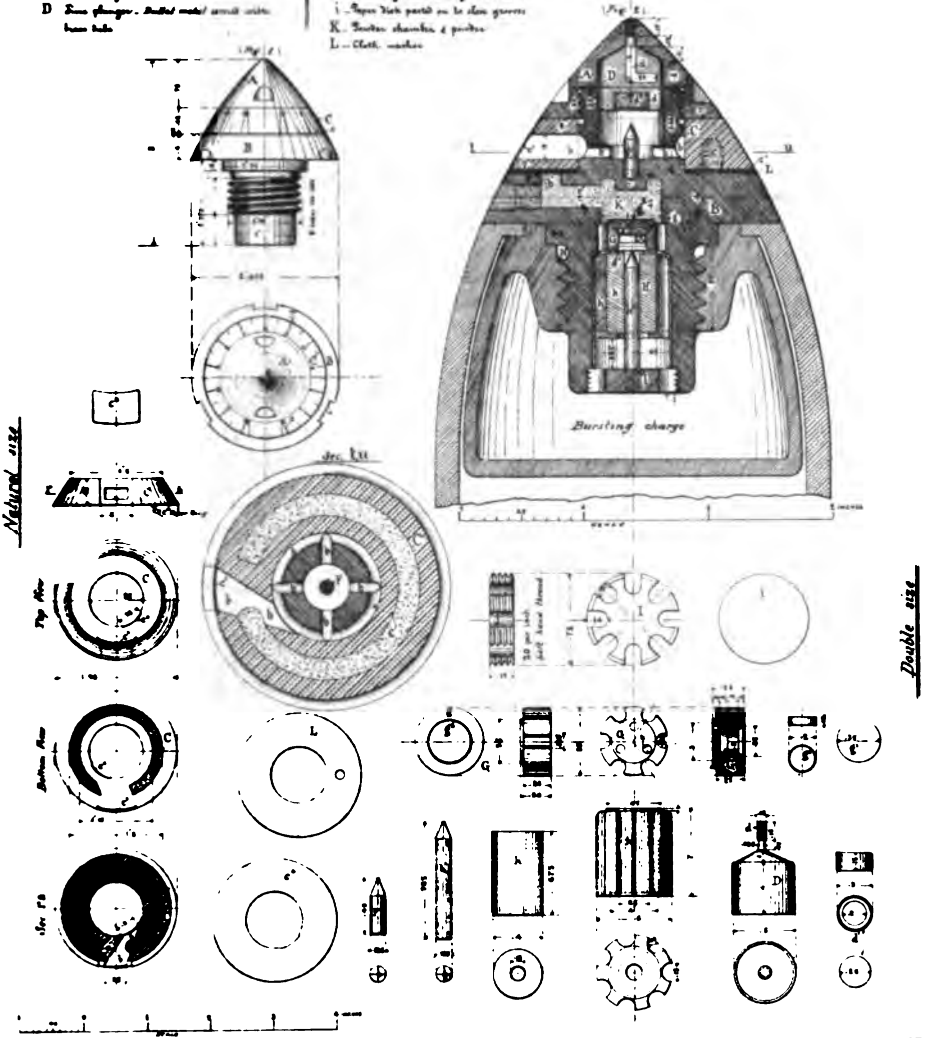
‡ Capt. Greer. § Lieut. Gibson.

# Col. D.W. Flagler's
# COMBINATION FUZE

## List of Parts

A – Cap – Bronze
B – Body – Bronze
b – Holes and Groove to communicate flame from time igniter to burning compos$^{n}$ ring
b' – Hole to communicate flame from burning composition ring to powder chamber
b$^{2}$ – Piece of Gauze pasted on b'.
C – Carrier – Alloy tin, antimony & copper
c – Time graduation
c' Burning composition ring
c$^{2}$ – Paper cover closing entrance to burning composition
c$^{3}$ – Zinc & Paper covers closing vent
c$^{4}$ – Paper ring on bottom
D Time plunger – Bullet metal screwed into brass tube
d – Suspension wire – Copper
d' – Igniter or Primer
d$^{2}$ – Fulminate
F – Firing pin for time igniter – Steel
G – Percussion igniter – Brass screw
g – Tinfoil ring to close grooves
g' – Fulminate
g$^{2}$ – Tinfoil cup & paper disk
g$^{3}$ – Zinc retaining disk
H – Percussion plunger
h – Bullet metal
h' – Grooved brass case
h$^{2}$ – Firing pin – steel
I – Bottom grooved closing disk – Brass
i – Paper disk pasted on to close grooves
K – Powder chamber & powder
L – Cloth washer

FRANKFORD ARSENAL
October 1888
D.W. Flagler
LIEUT. COLONEL OF ORDNANCE
COMMANDING



# APPENDIX 20.

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## *REPORT ON MANUFACTURE AND DESCRIPTION OF FRANKFORD ARSENAL COMBINATION FUSE WITH TUBULAR TIME TRAIN.*

(Three plates.)

### THE FRANKFORD ARSENAL COMBINATION FUSE (TUBULAR TIME TRAIN).

### DESCRIPTION. (See Plate I.)

This fuse comprises a time element and a percussion element. The body of the fuse is of bronze. The time element is assembled in and about the front part of the body while the percussion element is contained in the rear part. The time element consists of the concussion plunger, firing pin, cone, time train, cover, cap (clamping the cover), and clamping nut.

The concussion plunger is of bronze, cylindrical in shape, and contains the priming composition in a recess at its base. Its upper extremity is pierced to receive the safety pin, which prevents premature movement of the plunger during transportation or handling. Six lugs project from the periphery of the upper base and support the plunger on the fuse body after removal of the safety pin. They have a breaking weight of 30 pounds, sufficient to insure safety in handling after removal of the safety pin.

The firing pin is of steel and is driven into the body at the base ot the plunger channel.

The compressed powder ring is made of fine-grained powder pressed in a mold. It is held in its channel by a brass ring and is ignited from the primer through four holes in the fuse body.

The cone is made of an alloy of 50 parts lead, 25 tin, and 6 antimony, and is held in place on the fuse body by the clamping nut and a steel pin. The latter prevents independent rotation of the cone. A lip on the base fits tightly in a corresponding groove in the fuse body and serves as a gas-check, preventing possible premature ignition of the powder in the fuse chamber. A left-hand helicoidal groove on the cone receives the time train, which communicates by a connecting tube of bronze with the powder chamber of the fuse.

The cover is of brass and is held in place by the cap and a small projecting pin in the fuse body fitting into a slot in the base of the cover. It has a groove, corresponding to the time train on the cone, and is pierced with holes numbered from 1 to 15, corresponding to the seconds of graduation, the spaces between consecutive holes being subdivided into fifths and pierced or countersunk at the divisions.

The cap is of brass, and has two holes on its upper surface for the wrench.

The clamping nut is of brass. It holds the cone on the body.

### THE PERCUSSION ELEMENT.

This consists of the plunger (a brass case filled with an alloy of 16 parts lead and 1 part tin), a firing pin of steel, and the percussion igniter.

The percussion igniter is of brass. The surface of the igniter and plunger are grooved parallel to the axis of the fuse to furnish communication from the powder chamber of the fuse to the interior of the projectile. A tin-foil ring separates the powder charge of fuse from the igniter. A copper disk closes the rear passage to the igniter priming and withstands the pressure of the firing-pin point should the velocity of the shell be diminished sufficiently to permit forward movement of the plunger.

The bottom of the fuse is closed by a brass nut, grooved for the passage of the flame to the powder charge of the shell. The openings are covered by a paper or tin-foil disk.

The weight of the fuse is 16 ounces.

### ACTION AS A TIME FUSE.

For a whole number of seconds, as 12:

Pierce the time train and cone at right angles to the axis of the latter through the hole in the cover numbered 12. Remove the safety pin. When the gun is fired the shock of discharge breaks or straightens the lugs on the concussion plunger, which is thrown to the rear, striking the firing pin and igniting the priming. The flame ignites the compressed powder ring through the communicating holes, and thence reaches the time train through the hole in the cone. At the end of twelve seconds the flame reaches and ignites the charge of powder in the projectile.

The fuse may be cut to fifths of a second directly, and close approximation to tenths given by inclining the piercing tool.

### ACTION AS A PERCUSSION FUSE.

When the gun is fired the shock of discharge forces the percussion plunger to the rear, driving the firing pin through the plunger. When the projectile strikes an object the plunger is thrown forward, and the pin ignites the primer. The flame is communicated to the powder chamber of the fuse when it passes to the powder charge of the projectile.

### DEVELOPMENT AND MANUFACTURE.

The manufacture, up to the present time, has been in the experimental stage, temporary tools being improvised for the work. It is only since the fuse has been brought to its present degree of perfection that the tools necessary for economical production of the fuses in quantity have been put in process of fabrication.

The experimental work was inaugurated in the winter of 1888 and 1889 by Gen. (then Lieut. Col.) D. W. Flagler and continued during his command, at the conclusion of which a model of a 7-second fuse, patterned after the French, had been perfected for trial. Work was then suspended from November, 1889, till March, 1890, when, by orders of the Department, it was resumed by the late Col. T. G. Baylor, then in command, and fuses of the pattern referred to above, with some slight modification, were made and sent to the proving ground for trial. The results were very encouraging. (See Table I.)

It was then directed that the time element be lengthened to burn twenty-four seconds and a model of a Danish fuse (identical in principle with the former), which was understood to have given satisfactory results, was taken as a basis for future trials. Mealed powder had been used for the train in the 7-second fuse, but the increased length of train now adopted required a slower composition in order that the size and weight of the fuse might be kept within suitable limits.

A 24-second fuse was accordingly made and tried at the proving ground, but with very unsatisfactory results as far as the time element was concerned.

From that date the time was taken up in various trials to determine, if possible, the cause of failure.

Intelligent action required that one or more fuses should be subjected to the shock of discharge, with the least distortion possible, and recovered for examination. A fuse with percussion plunger removed was screwed in a housing which was then inserted in a shell through the base, the latter being closed by the housing. This method was suggested by Capt. Zalinski, Fifth Artillery. On firing it was found that the brass cover of the plunger (the plunger, modeled after the Danish, then consisted of a brass case filled with alloy of lead and tin) had been forced into the vents around the firing pin, closing them and shutting off the flame from the time train, which was not ignited. This and the other experiments suggested several modifications as follows:

(1) A solid concussion plunger of bronze instead of the brass case filled with alloy.

(2) A ledge at the base of the plunger channel to stop the plunger after striking the firing pin, thus preventing possible closing of the vents.

(3) Reduction of the number and size of vents so as to increase intensity of flame through each.

(4) Use of a compressed powder ring surrounding the vents, thus reinforcing the flame from plunger primer.

(5) Omission of the vent bored in cone. This vent was supposed to be necessary to enhance the movement of the inflamed gas from the primer and compressed powder ring. It is not needed with the mealed powder train now used, though it may be necessary with a slower composition.

(6) Priming composition made more sensitive.

(7) Steel pin used for concussion primer instead of bronze. The bronze pin was turned on the body of the fuse. This part of the casting was sometimes faulty, making the pin unreliable.

For the next trial the length of the fuse was ordered limited to fifteen seconds, which permitted the use of mealed powder, used in the 7-second fuse, instead of the slower composition used in the trials of October 18, 1890. This was considered advantageous.

On July 7 and 8, 1891, fuses embodying these changes were tested at the proving ground, with the following satisfactory results: (See Table II.)

| No. fired. | Cut. | Acted by time. | Average time of flight. | |
|---|---|---|---|---|
| | *Inches.* | | | *Seconds.* |
| 20 | 0.5 | All. | 1st observer .... | 0.96 |
| | | | 2d observer ..... | 0.97 |
| | | | 3d observer ..... | 1.06 |
| | | | 4th observer .... | 1.13 |
| 12 | 2.75 | [*]11 | 1st observer .... | 3.89 |
| | | | 2d observer ..... | 4.16 |
| | | | 3d observer ..... | 4.29 |
| 3 | 6.5 | [†]2 | .................. | 10.125 |
| 1 | 6 | 1 | .................. | 9.5 |
| 2 | 5.5 | 2 | 1st observer .... | 8.75 |
| | | | 2d observer ..... | 8.98 |

[*] One shot did not reach target. No burst was seen by either observer.
[†] First shot burst on striking ground 600 yards in rear of target.

The model used in these latter tests is the one shown in Pl. I, and which has been adopted for manufacture.

It should be borne in mind that the work was new (the data at hand at the outset being very limited) and involved much tedious and patient experiment, mainly in the following direction:

(1) With different initial diameters of pipe.

(2) With different metals for time train.

(3) With different methods of putting the train in the groove.

(4) Varying size and shape of train groove.

(5) Varying the density of the charge and reducing the diameter of the resulting train to reduce the quantity of heat developed in burning.

(6) Various powders for charging the time train.

(7) Many changes of detail in the form and interior arrangement of the time element to correct defects indicated by trial at the proving ground.

The following details of the foregoing will be of interest:

(1) Metallic pipe for time train. Lead was used in the first trials, and is now used for the train. It possesses these properties, which are advantageous:

It draws easily and uniformly. It has a low melting point, causing the train to vent itself in burning. Ease of ventage has a marked effect upon uniformity of burning.

Tin is said to have been used with some success abroad, and trials with it have been made here. The results of the first trials were not as satisfactory as with lead. The difficulties met with were overcome later, and results were obtained (at rest) which did not differ materially from those with lead. So far as known, lead is generally used for fuses of this kind, but more extended trials might indicate the desirability of using tin. The latter is, however, harder to draw than lead, and the cost is greater.

Some copper trains were burned in straight lengths by direction of the Department and at the request of Capt. Zalinski, Fifth Artillery. The trials showed its undesirability for the purpose on account of the high melting point of copper which precluded any ventage other than through the end, making the rate of burning irregular except in very short lengths.

Attempt was made to draw tubes from aluminum, but without success, on account of the impracticability of annealing. Hot water is said to answer in wire-drawing this metal, but did not suffice for tubes, as far as the limited trials possible here indicated.

(2) Different methods of putting the train in the groove, as follows: Having the groove of sufficient size to permit the train being rolled in freely.

Giving an oblong cross section to the groove, the shorter axis of this section being less than the diameter of the train. The latter is flattened slightly to permit its entering the groove, and is then rolled flat on the exterior. The latter method has been adopted, as it is thought the rolling partially restores the train charge after the disintegration caused by coiling. The results by this method are satisfactory.

(3) Various compositions have been tried, giving different densities of charge and different rates of burning, according to the length of fuse required.

### MANUFACTURE.

There are thirteen principal parts to the fuse, detailed description of the manufacture of a majority of which is unnecessary.

The body is cast of bronze, and is turned and finished to dimensions shown in Pl. II.

The cover is made of a disk of brass 3.25 inches in diameter and 0.55 inch thick, being stamped to the form required by a punch and die. The disk will be cut and the cover stamped out in one operation on a double acting press, as follows:

A circular cutter cuts the disk. A punch working within the cutter forces the disk into the die. It is then finished and prepared on the exterior for graduation.

The cap, nut, and closing screw are cut from rolled brass and finished as shown in Pl. II.

The cone is cast from an alloy of lead, tin, and antimony. It is squared on the ends, the gas check ledge turned on the base, and the surface grooved for reception of the train.

The concussion plunger is made of bronze. It being a shorter alloy than brass, the lugs break more readily.

The time train is made as follows:

A lead pipe, 12 inches long, 0.80 inch outside and 0.62 inch inside diameter, is charged with about 1,000 grains of mealed powder, 30 grains being put in at a time, and settled by three slight taps with a mallet on a drift. Both ends are then closed, and the pipe is reduced in 70 draws to 0.152 inch outside diameter. The length of the resulting train is about 23 feet. About 2 feet are cut from each end and rejected.

Comparative tests are made by burning lengths of 1 foot each.

Pl. III, Fig. II, shows the charged pipe prepared for drawing, one end being reduced for passing through the die.

For the first drawing the reduction in diameter is 0.02 inch. This diminishes to the last drawing, when it is 0.002 inch.

For a 15-second fuse a length of 10.5 inches is taken.

The time-train groove being 0.13 inch wide and 0.145 inch deep, necessitates a flattening of the train while it is being put in the groove. A roller then forces it well into the groove and flattens the surface, which is covered with a coat of shellac. A strip of asbestus cloth is fastened over the train at its junction with the tube connecting it with the powder chamber of the fuse.

The Schultz chronoscope is used in testing fuses for rate of burning "at rest," making possible more accurate comparisons of results "at rest" than can be obtained with the stop watch, where personal error will enter.

For the present, the graduation for service will be determined experimentally on the proving ground.

TABLE I.—*Frankford Arsenal combination French modified fuse (model April, 1890), fired at Sandy Hook proving ground, April 28 and June 2, 1890.*

| No. | Fuse set. | Observed times. | | | Burst from 1,000-yards target. | Remarks. |
|---|---|---|---|---|---|---|
| | *Seconds.* | *Secs.* | *Secs.* | *Secs.* | | |
| 1 | .......... | 1.8 | ........ | ........ | 610 feet front.......... | Elevation, 1° 0′ 2″. |
| 2 | .......... | 2.2 | ........ | ........ | 660 feet front.......... | |
| 3 | .......... | 1.9 | ........ | ........ | 660 feet front.......... | |
| 4 | .......... | 2.3 | ........ | ........ | 310 feet front.......... | |
| 5 | .......... | 2.8 | ........ | ........ | Just in rear.......... | |
| 6 | .......... | 2.2 | ........ | ........ | 10 feet rear.......... | |
| | | | June 2, 1890. | | | |
| 7 | 2 | 1.6 | Lost. | Lost. | Short of 1,000-yards target. | |
| 8 | 2 | 1.6 | 1.4 | 1.6 | | |
| 9 | 4 | Lost. | 3.2 | 3.6 | Short of 1-mile target.. | Elevation, 2° 50′. |
| 10 | 4 | 3.4 | Lost. | 3.2 | | |
| 11 | 4 | 3.4 | 3.4 | 3.2 | | |
| 12 | 6 | 5.4 | 5.2 | Lost. | Beyond 1-mile target.. | Elevation, 4° 00′. |
| 13 | 6 | 5.8 | 5.2 | 5.2 | | |
| 14 | 6 | 5.8 | 5.2 | 5.4 | | |

TABLE II.—*Frankford Arsenal combination fuse, fired at Sandy Hook proving ground, July 7, 1891.*

| No. | Cut. | Observed times. | | | | Remarks. |
|---|---|---|---|---|---|---|
| | | Capt. Baker. (Watch.) | Mr. J. H. Gill. (Clock.) | Lieut. Gibson. (Watch.) | Lieut. Wheeler, (Watch.) | |
| | *Inch.* | *Seconds.* | *Seconds.* | *Seconds.* | *Seconds.* | |
| 1 | 0.5 | 1 | 1.2 | 1.25 | 1.75 | Elevation, 10°. Average times: Mr. Gill, .96 second; Lieut. Gibson, 1.11 seconds; Lieut. Wheeler, .97 second; Capt. Baker, 1.06 seconds. |
| 2 | 0.5 | 1.25 | .......... | 1 | 1 | |
| 3 | 0.5 | .......... | .......... | .75 | .75 | |
| 4 | 0.5 | 1.25 | 1.3 | 1.125 | .75 | |
| 5 | 0.5 | 1.25 | 1 | 1.125 | .75 | |
| 6 | 0.5 | 1.25 | .9 | 1 | .75 | |
| 7 | 0.5 | .......... | .8 | 1 | 1 | |
| 8 | 0.5 | 1.5 | 1 | 1.25 | 1.25 | |
| 9 | 0.5 | 1.25 | .9 | 1.25 | 1 | |
| 10 | 0.5 | .......... | .9 | 1.375 | 1 | |
| 11 | 0.5 | 1 | 1 | 1.125 | .75 | |
| 12 | 0.5 | 1 | 1 | 1 | 1 | |
| 13 | 0.5 | 1 | .......... | 1.5 | 1 | |
| 14 | 0.5 | .75 | .8 | 1 | .75 | |
| 15 | 0.5 | .75 | .8 | 1 | 1 | |
| 16 | 0.5 | .75 | .8 | 1.125 | 1 | |
| 17 | 0.5 | 1 | .......... | 1.125 | 1 | |
| 18 | 0.5 | .......... | .......... | 1 | 1 | |
| 19 | 0.5 | .75 | 1 | 1 | .......... | |
| 20 | 0.5 | 1.25 | 1 | 1.25 | .......... | |

JULY 7 AND 8, 1891. RANGE, 1 MILE.

| No. | Cut. | Observed times. | | | Burst from target. | Remarks. |
|---|---|---|---|---|---|---|
| | | Capt. Baker. (Watch.) | Mr. J. H. Gill. (Clock.) | Lieut. Gibson. (Watch.) | | |
| | *Inches.* | *Seconds.* | *Seconds.* | *Seconds.* | *Yards.* | |
| 1 | 2.75 | 5.00 | 4 | 4.5 | 25 rear...... | Elevation 3°. Average times: Lieut. Gibson, 4.29 seconds; Mr. Gill, 3.89 seconds; Capt. Baker, 4.16 seconds. |
| 2 | 2.75 | .......... | .......... | 4.25 | 30 front .... | |
| 3 | 2.75 | .......... | 4.2 | 4.5 | 8 rear...... | |
| 4 | 2.75 | 4.00 | 3.6 | 4.25 | 34 front..... | |
| 5 | 2.75 | Did not reach target........ | | | .............. | |
| 6 | 2.75 | 4.00 | .......... | 4.25 | 82 front .... | |
| 7 | 2.75 | 4.00 | 3.75 | 4.125 | 39 front .... | |
| 8 | 2.75 | 4.00 | 4.2 | 4.25 | 22 front .... | |
| 9 | 2.75 | 4.00 | 3.75 | 4.25 | 28 front .... | |
| 10 | 2.75 | 4.25 | 3.75 | 4.50 | 16 front .... | |
| 11 | 2.75 | 4.00 | 3.8 | 4.125 | 15 front .... | |
| 12 | 2.75 | 4.25 | 4 | 4.25 | 10 rear...... | |

**TABLE II.**—*Frankford Arsenal combination fuse, fired at Sandy Hook proving ground, July 7, 1891*—Continued.

JULY 8, 1891. RANGE, 3,000 YARDS.

| No. | Cut. | Observed times. | | Gun elevation. | Burst from target. |
|---|---|---|---|---|---|
| | | Capt. Baker. (Watch.) | Lieut. Gibson. | | |
| | *Inches.* | *Seconds.* | *Seconds.* | ° | *Yards.* |
| 1 | 6.5 | .................. | .................. | 6 | 600 rear.* |
| 2 | 6.5 | .................. | 10.25 | 8 | 300 rear. |
| 3 | 6.5 | 10 | 10 | 7 | 300 rear. |
| 4 | 6 | 9.5 | 9.5 | 7 | 270 rear. |
| 5 | 5.5 | 9 | 9.25 | 7 | 133 rear. |
| 6 | 5.5 | 8.5 | 8.625 | 7 | 91 rear. |

*On striking ground.

*Record of firing with 3.2-inch B. L. rifle (steel), No. 18, West*

| Date. | | No. of fire. | Powder. | | Projectile. | | Elevation. | Fuse. | Time of flight. |
|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1890. | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ′ | | *Secs.* |
| Apr. 28 | P. M .... | 1028 | Du Pont's I. K. G. Density, 1.725. Granulation, 2,500. | 3 12 | Cast-iron shell, 3 calibers in length, altered to receive Frankford Arsenal point combination fuse. Lot 270. | *13 7½ | 1 2 | French modified point combination, pattern of April, 1890. | 1½ |
| Apr. 28 | | 1029 | | 3 12 | | *13 7½ | 1 2 | | 2½ |
| Apr. 28 | | 1030 | | 3 12 | | *13 7½ | 1 2 | | 1 8/10 |
| Apr. 28 | | 1031 | | 3 12 | | *13 7½ | 1 2 | | 2 1/10 |
| Apr. 28 | | 1032 | | 3 12 | | *13 7½ | 1 2 | | 2½ |
| Apr. 28 | | 1033 | | 3 12 | | *13 7½ | 1 2 | | 2½ |

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* Including 1 pound 3½ ounces fuse, 6 ounces musket powder, bursting charge.

*Point Foundry, at Sandy Hook, N. J., April 28, 1890.*

| | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|
| Fired at screen 120 yards in front of 1,000-yards target. | Fuse set at 2 seconds. Shell burst 250 feet in front of screen. |
| Fired at 1,000-yards target. | Fuse set at 2 seconds. Shell burst 600 feet in front of target. |
| | Fuse set at 2 seconds. Shell burst 660 feet in front of target. |
| | Fuse set at 4 seconds. Shell burst 310 feet in front of target. |
| | Fuse set at 4 seconds. Shell passed through target and burst just beyond. |
| Fired at screen 120 yards in front of 1,000-yards target.<br>Firing conducted by the proof officer. | Fuse set at 4 seconds. Shell passed through screen and burst 10 feet beyond. |

*Record of firing with 3.2-inch B. L. rifle (steel), No. 18, West*

[Object of firing, to determine

| Date. | Cannon. | No. of fire. | Powder. | | Projectile. | | Elevation. | Fuse. | Recoil. |
|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1890. | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ′ | | *Feet.* |
| June 2 | 3.2-inch B.L. rifle (steel), No. 18, West Point Foundry. | 1081 | Du Pont's I. K. G. Density, 1.725. Granulation, 2,500. | 3 12 | Cast-iron shell, 3 calibers in length, altered to receive Frankford Arsenal combination fuse. Lot 270. | 11 14<br>*1 4½<br>†5<br>13 7½ | 1 02 | French modified point combination fuse, pattern of April, 1890. Frankford Arsenal. | 11 |
| June 2 | | 1082 | | 3 12 | | 11 14<br>*1 4<br>†5<br>13 7 | 1 02 | | 10½ |
| June 2 | | 1083 | | 3 12 | | 11 14<br>*1 4½<br>†5½<br>13 8 | 2 50 | | 11 |
| June 2 | | 1084 | | 3 12 | | 11 12<br>*1 4½<br>†5½<br>13 6 | 2 50 | | 11½ |
| June 2 | | 1085 | | 3 12 | | 11 14<br>*1 3½<br>†5½<br>13 7 | 2 50 | | 7 |
| June 2 | | 1086 | | 3 12 | | 11 14<br>1 4½<br>†5½<br>18 8 | 4 00 | | 11 |
| June 2 | | 1087 | | 3 12 | | 11 15<br>*1 4½<br>†5½<br>13 9 | 4 00 | | 11½ |
| June 2 | | 1088 | | 3 12 | | 11 11<br>*1 4<br>†5½<br>13 4½ | 4 00 | | 11½ |

* Fuse.

† Musket powder, bursting charge.

***Point Foundry, at Sandy Hook, N. J., June 2, 1890.***

**time of burning of fuses.]**

| Fuse set at— | Time of flight. (Stop-watch held by Lieut. Col. A. Mordecai, O. D.). | Time of flight. (Stop-watch held by Capt. J. C. Ayres, O. D.). | Time of flight. (Stop-watch held by Lieut. O. M. Lissak, O. D.). | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|---|---|
| | | | | Gun mounted on Buffington steel field carriage No. 1, with old spiral-spring brakes. Cannon friction primers (experimental), with modified priming. | |
| *Secs.* | *Secs.* | *Secs.* | *Secs.* | | |
| 2 | 1⅜ | Lost... | Lost... | Fired in direction of 1,000-yards target. | Burst short of 1,000-yards target. |
| 2 | 1⅜ | 1⅜ | 1⅜ | | Do. |
| 4 | Lost... | 3⅛ | 3⅞ | Fired in direction of 1-mile target. | Burst short of 1-mile target. |
| 4 | 3⅜ | Lost... | 3⅛ | | Do. |
| 4 | 3⅜ | 3⅞ | 3⅛ | | Do. |
| 6 | 5⅜ | 5⅛ | Lost... | | Burst beyond 1-mile target. |
| 6 | 5⅝ | 5⅛ | 5⅛ | | Do. |
| 6 | 5⅜ | 5⅛ | 5⅜ | | Do. |

Difficulty in closing breechblock at each fire, owing to length of cartridge.
Firing conducted by the proof officer.

*Record of firing with 3.2-inch B. L. rifle (steel), No. 18, West Point*

[Object of firing, to test Frankford Arsenal

| Date. | | No. of fire. | Powder. | | Projectile. | | Elevation. | Fuse cut at— | Fuse marked. | Recoil. | Wind, strength and direction. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight | Kind. | Weight | | | | | |
| 1890. | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ′ | *Secs.* | | *Feet.* | |
| Oct. 27 | P. M. | 1312 | Du Pont's I. K. H. Lot 1. Density, 1.725. Granulation, 2,050. | 3 12 | Shell (lot 279), with Frankford Arsenal combination fuse (modified Danish). | 12 0<br>*5<br>†1 0<br>13 5 | 8 00 | 10 | A | 12 | From right and rear, 25 miles an hour. |
| Oct. 27 | | 1313 | | 3 12 | | 12 0<br>*5<br>†1 0<br>13 5 | 10 00 | 10 | ‖A | 12 | |
| Oct. 27 | | 1314 | | 3 12 | | 12 0<br>*5<br>†1 0<br>13 5 | 10 00 | 10 | A | 12 | |
| Oct. 27 | | 1315 | | 3 12 | | 12 0<br>*5<br>†1 0<br>13 5 | 12 00 | 10 | ¶B | 11 | |
| Oct. 27 | | 1316 | | 3 12 | | 12 0<br>*5<br>†1 0<br>13 5 | 5 00 | 5 | B | 12 | |
| Oct. 27 | | 1317 | | 3 12 | | 12 0<br>*5<br>†1 0<br>13 5 | 5 00 | 5 | B | 12 | |
| Oct. 28 | | 1329 | | 3 12 | Service shell. Lot 229. | 12 14<br>‡6<br>§4<br>13 8 | ...... | ...... | ...... | 10 | From rear and right, 17 miles an hour. |
| Oct. 28 | | 1330 | | 3 12 | Shell (lot 279), with Frankford Arsenal combination fuse (modified Danish). | 12 0<br>†1 0<br>13 0 | ...... | 1 | A | 10 | |
| Oct. 28 | | 1331 | | 3 12 | | 12 0<br>†1 0<br>13 0 | ...... | 1 | B | 10 | |

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* Rifle powder, bursting charge.
† Fuse.
‡ Sand.
§ Lead.
‖ Fuse "A," Frankford Arsenal percussion plunger.
¶ Fuse "B," modified Danish percussion plunger.

(5617-'90.)

*Foundry, at Sandy Hook, N. J., from October 27 to October 28, 1890.*

**combination fuses (modified Danish).]**

| | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|
| Gun mounted on Buffington steel field carriage (light), No. 17, with old spiral spring brakes. De Bange gas-check. Cannon friction primers (experimental), with modified priming, March, 1890. Fired from platform on fort wall. | |
| Aimed at left edge of 3,000-yards target | Struck water at about 4,000 yards; was not observed in time to judge with certainty whether or not it exploded. |
| | Struck water at about 4,000 yards; burst on striking. Time of flight, 15 seconds. |
| | Struck water at about 4,000 yards; burst on striking. Time of flight, 14½ seconds. |
| | Gun hung fire, caused by eroded condition of vent piece. Struck water at about 4,500 yards; bursting doubtful. Time of flight, 17½ seconds. |
| Aimed to the right of 1-mile target | Struck water at 3,000 yards; burst on striking. Time of flight, 9½ seconds. |
| Fired at 3,000-yards target | Struck 40 feet behind 3,000-yards target; burst on striking ground. Time of flight, 8¾ seconds. |
| Fired into seacoast butt, left section; to be recovered. | Frankford Arsenal percussion plunger. |
| | Modified Danish percussion plunger. |
| Shell recovered, but fuses destroyed to such an extent by impact that no information can be gained from them.<br>Gun sighted by Lieut. W. W. Gibson, Ordnance Department. Fall of projectile observed by Lieut. O. M. Lissak, Ordnance Department.<br>Firing conducted by the proof officer. | |

*Record of firing with 3.2-inch B. L. rifle (steel), No. 18, West*

[Object of firing, to test Frankford Arsenal

| Date. | | No. of fire. | Powder. | | Projectile. | | Elevation. | Fuse cut— | Fuse marked. | Recoil. | Wind, strength, and direction. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight | Kind. | Weight | | | | | |
| 1890. | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ′ | *Secs.* | | *Feet.* | |
| Nov. 19 | A. M. | 1407 | Du Pont's I. K. H. Lot 1. Density, 1.725. Granulation, 2050. | 3 12 | Shell (lot 279), Frankford Arsenal combination fuse (modified Danish). | 12 0<br>*5<br>†1 0<br>13 5 | 2 00 | 2 | ‡B | 10 | From front and right, 13 miles an hour. |
| Nov. 19 | | 1408 | | 3 12 | | 12 0<br>*5<br>†1 0<br>13 5 | 2 00 | 2 | §A | 10 | |

* Rifle powder, bursting charge.
† Fuse.
‡ Fuse "B," modified Danish percussion plunger.
§ Fuse "A," Frankford Arsenal percussion plunger.

*Point Foundry, at Sandy Hook, N. J., November 19, 1890.*

**combination fuses (modified Danish).]**

| | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|
| Gun mounted on Buffington steel field carriage (light), No. 17, with old spiral-spring brakes. De Bange gas-check. Cannon friction primers (experimental), with modified priming, March, 1890. | |
| Fired down the beach. Aimed to the left of 1-mile target. | Four retaining strips left on igniter; others removed. Burst on striking ground. Time to striking ground, 5 seconds. This fuse had previously been bored to 10 seconds. |
| | Four retaining strips left on igniter; others removed. Burst on striking ground. Time to striking ground, 5 seconds. |
| Fall of projectile and time of flight observed by Lieut. W. W. Gibson, Ordnance Department. Firing conducted by Capt. D. A. Lyle, Ordnance Department, assistant proof officer. | |

***Record of firing with 3.2-inch B. L. rifle (steel), No. 18, West***

**[Object of firing, trial of Frankford Arsenal combination fuse (modified Danish)**

| Date. | | No. of series. | No. of fire. | Powder. | | Projectile. | | Elevation. | Fuse marked | Fuse set at— | Recoil. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Kind. | Weight. | Kind. | Weight. | | | | |
| | | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ′ | | *Secs.* | *Feet.* |
| 1890.<br>Dec. 18 | P. M. | 11 | 1441 | Du Pont's I. K. H. Lot 16. Density, 1.725. Granulation, 2,524. | 3 12 | Shell (lot 279), with Frankford Arsenal combination fuse (modified Danish). | 12 0<br>*5<br>†1 0<br>13 5 | 8 35 | ‡A | 5 | 9 |
| Dec. 18 | | 12 | 1442 | | 3 12 | | 12 1<br>*6<br>†1 0<br>13 7 | 4 00 | §B | 3 | 10 |

* Rifle powder, bursting charge.
† Fuse.
‡ "A," Frankford Arsenal percussion plunger.
§ "B," modified Danish percussion plunger.

***Record of firing with 3.6-inch B. L. field rifle (steel), No. 1,***

**[Object of firing, to test Frankford Arsenal combination**

| Date. | | No. of series. | No. of fire. | Powder. | | Projectile. | | Elevation. | Fuse marked. | Fuse set at— | Recoil. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Kind. | Weight. | Kind. | Weight. | | | | |
| 1890. | | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ′ | | *Secs.* | *Feet.* |
| Dec. 18 | P. M. | ...... | 167 | Du Pont's I. K. H. Lot 16. Density 1.725. Granulation, 2,524 | 4 0 | Shell (banded), experimental. Lot 249. | 19 1<br>15 sand.<br>20 0 | 10 0 | ...... | ...... | 11 |
| Dec. 18 | | 13 | 168 | | 4 0 | Shell (banded) experimental. Lot 249, with Frankford Arsenal combination fuse (modified Danish) in housing. | 20 7 | 10 0 | *A | 5 | 12 |
| Dec. 18 | | 14 | 169 | | 4 0 | | 20 0 | 10 0 | †B | 3 | 12 |

* "A," Frankford Arsenal percussion plunger.
† "B," Modified Danish percussion plunger.

*Point Foundry, at Sandy Hook, N. J., December 18, 1890.*

with modified primer for igniting time train and with quick match inserted.]

| Wind, strength and direction. | Time of flight. Secs. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|
| | | Gun mounted on carriage for 3-inch gun (altered muzzle loader), with old spiral-spring brakes. De Bange gas-check. Cannon friction primers (experimental), with modified priming, March, 1890. | |
| Wind from rear, 20 miles an hour. | ...... | Fired to sea.................................. | Shell did not burst. |
| | 4½ | Aimed between 1 mile and 3,000-yard targets. | Shell burst. |
| | | Firing conducted by the proof officer. | |

*Watervliet Arsenal, at Sandy Hook, N. J., December 18, 1890.*

fuses (modified Danish), fired in housing and recovered.]

| Wind, stren'th and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|
| | Gun mounted on Buffington steel field carriage, No. 4. Spiral-spring brakes, clevis attachment. De Bange gas-check. Cannon friction primers (experimental), with modified priming, March 1890. | |
| From rear, 20 miles an hour. | Fired into sand butt, section 1.......... | Sighting shot. |
| | | Rear plunger removed before firing. On firing front plunger had operated, exploding percussion composition, brass covering of plunger forced into vents surrounding steel point, closing them. Lead cylinder of plunger driven forward into point. Time composition not ignited. |
| | | Rear plunger removed before firing. On firing front plunger had operated, exploding percussion composition; brass covering of plunger forced into vents surrounding steel point, partially closing them. Lead cylinder of plunger driven forward into point. Time train ignited and consumed. |
| | Firing conducted by the proof officer. | |

*Record of firing with 3.2-inch B. L. rifle (steel), No. 18, West*

| Date. | | No. of fire. | Powder. | | Projectile. | | Elevation. | Fuse. | Time of flight. |
|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1890. | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ′ | | *Secs.* |
| Apr. 28 | P. M .... | 1028 | Du Pont's I. K. G. Density, 1.725. Granulation, 2,500. | 3 12 | Cast-iron shell, 3 calibers in length, altered to receive Frankford Arsenal point combination fuse. Lot 270. | *13 7⅛ | 1 2 | French modified point combination, pattern of April, 1890. | 1⅜ |
| Apr. 28 | | 1029 | | 3 12 | | *13 7⅛ | 1 2 | | 2⅛ |
| Apr. 28 | | 1030 | | 3 12 | | *13 7⅛ | 1 2 | | 1⁹⁄₁₀ |
| Apr. 28 | | 1031 | | 3 12 | | *13 7⅛ | 1 2 | | 2⁵⁄₁₀ |
| Apr. 28 | | 1032 | | 3 12 | | *13 7⅛ | 1 2 | | 2⅛ |
| Apr. 28 | | 1033 | | 3 12 | | *13 7⅛ | 1 2 | | 2⅛ |

* Including 1 pound 3⅛ ounces fuse, 6 ounces musket powder, bursting charge.

*Point Foundry, at Sandy Hook, N. J., April 28, 1890.*

| | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|
| Fired at screen 120 yards in front of 1,000-yards target. | Fuse set at 2 seconds. Shell burst 250 feet in front of screen. |
| Fired at 1,000-yards target | Fuse set at 2 seconds. Shell burst 660 feet in front of target. |
| | Fuse set at 2 seconds. Shell burst 660 feet in front of target. |
| | Fuse set at 4 seconds. Shell burst 310 feet in front of target. |
| | Fuse set at 4 seconds. Shell passed through target and burst just beyond. |
| Fired at screen 120 yards in front of 1,000-yards target.<br>Firing conducted by the proof officer. | Fuse set at 4 seconds. Shell passed through screen and burst 10 feet beyond. |

*Record of firing with 3.2-inch B. L. rifle (steel), No. 18, West*

[Object of firing, to determine

| Date. | Cannon. | No. of fire. | Powder. |  | Projectile. |  | Elevation. | Fuse. | Recoil. |
|---|---|---|---|---|---|---|---|---|---|
|  |  |  | Kind. | Weight. | Kind. | Weight. |  |  |  |
| 1890. |  |  |  | *Lbs. Oz.* |  | *Lbs. Oz.* | ° ′ |  | *Feet.* |
| June 2 | 3.2-inch B.L. rifle (steel), No. 18, West Point Foundry. | 1081 | Du Pont's I. K. G. Density, 1.725. Granulation, 2,500. | 3 12 | Cast-iron shell, 3 calibers in length, altered to receive Frankford Arsenal combination fuse. Lot 270. | 11 14<br>*1 4½<br>†5<br>13 7½ | 1 02 | French modified point combination fuse, pattern of April, 1890. Frankford Arsenal. | 11 |
| June 2 |  | 1082 |  | 3 12 |  | 11 14<br>*1 4<br>†5<br>13 7 | 1 02 |  | 10½ |
| June 2 |  | 1083 |  | 3 12 |  | 11 14<br>*1 4¾<br>†5¼<br>13 8 | 2 50 |  | 11 |
| June 2 |  | 1084 |  | 3 12 |  | 11 12<br>*1 4¾<br>†5¼<br>13 6 | 2 50 |  | 11½ |
| June 2 |  | 1085 |  | 3 12 |  | 11 14<br>*1 3½<br>†5½<br>13 7 | 2 50 |  | 7 |
| June 2 |  | 1086 |  | 3 12 |  | 11 14<br>1 4½<br>†5½<br>13 8 | 4 00 |  | 11 |
| June 2 |  | 1087 |  | 3 12 |  | 11 15<br>*1 4¾<br>†5¼<br>13 9 | 4 00 |  | 11½ |
| June 2 |  | 1088 |  | 3 12 |  | 11 11<br>*1 4<br>†5½<br>13 4½ | 4 00 |  | 11½ |

* Fuse. † Musket powder, bursting charge.

*Point Foundry, at Sandy Hook, N. J., June 2, 1890.*

**time of burning of fuses.]**

| Fuse set at— | Time of flight. (Stop-watch held by Lieut. Col. A. Mordecai, O. D.). | Time of flight. (Stop-watch held by Capt. J. C. Ayres, O. D.). | Time of flight. (Stop-watch held by Lieut. O. M. Lissak, O. D.). | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|---|---|
| | | | | Gun mounted on Buffington steel field carriage No. 1, with old spiral-spring brakes. Cannon friction primers (experimental), with modified priming. | |
| *Secs.* | *Secs.* | *Secs.* | *Secs.* | | |
| 2 | 1⅞ | Lost... | Lost... | Fired in direction of 1,000-yards target. | Burst short of 1,000-yards target. |
| 2 | 1⅜ | 1⅜ | 1⅞ | | Do. |
| 4 | Lost... | 3¼ | 3⅜ | Fired in direction of 1-mile target. | Burst short of 1-mile target. |
| 4 | 3⅜ | Lost... | 3¼ | | Do. |
| 4 | 3⅜ | 3⅞ | 3¼ | | Do. |
| 6 | 5⅜ | 5¼ | Lost... | | Burst beyond 1-mile target. |
| 6 | 5⅝ | 5¼ | 5¼ | | Do. |
| 6 | 5⅛ | 5¼ | 5⅞ | | Do. |

Difficulty in closing breechblock at each fire, owing to length of cartridge.

Firing conducted by the proof officer.

*Record of firing with 3.2-inch B. L. rifle (steel), No. 18, West Point*

[Object of firing, to test Frankford Arsenal

| Date. | | No. of fire. | Powder. | | Projectile. | | Elevation. | Fuse cut at— | Fuse marked. | Recoil. | Wind, strength and direction. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight | Kind. | Weight | | | | | |
| 1890. | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ′ | *Secs.* | | *Feet.* | |
| Oct. 27 | P.M. | 1312 | Du Pont's I. K. H. Lot 1. Density, 1.725. Granulation, 2,050. | 3 12 | Shell (lot 279), with Frankford Arsenal combination fuse (modified Danish). | 12 0<br>*5<br>†1 0<br>13 5 | 8 00 | 10 | A | 12 | From right and rear, 25 miles an hour. |
| Oct. 27 | | 1313 | | 3 12 | | 12 0<br>*5<br>†1 0<br>13 5 | 10 00 | 10 | ‖ A | 12 | |
| Oct. 27 | | 1314 | | 3 12 | | 12 0<br>*5<br>†1 0<br>13 5 | 10 00 | 10 | A | 12 | |
| Oct. 27 | | 1315 | | 3 12 | | 12 0<br>*5<br>†1 0<br>13 5 | 12 00 | 10 | ¶ B | 11 | |
| Oct. 27 | | 1316 | | 3 12 | | 12 0<br>*5<br>†1 0<br>13 5 | 5 00 | 5 | B | 12 | |
| Oct. 27 | | 1317 | | 3 12 | | 12 0<br>*5<br>†1 0<br>13 5 | 5 00 | 5 | B | 12 | |
| Oct. 28 | | 1329 | | 3 12 | Service shell. Lot 229. | 12 14<br>‡6<br>§4<br>13 8 | ...... | ...... | ...... | 10 | From rear and right, 17 miles an hour. |
| Oct. 28 | | 1330 | | 3 12 | Shell (lot 279), with Frankford Arsenal combination fuse (modified Danish). | 12 0<br>†1 0<br>13 0 | ...... | 1 | A | 10 | |
| Oct. 28 | | 1331 | | 3 12 | | 12 0<br>†1 0<br>13 0 | ...... | 1 | B | 10 | |

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* Rifle powder, bursting charge.
† Fuse.
‡ Sand.
§ Lead.
‖ Fuse "A," Frankford Arsenal percussion plunger.
¶ Fuse "B," modified Danish percussion plunger.

*Foundry, at Sandy Hook, N. J., from October 27 to October 28, 1890.*

**combination fuses (modified Danish).]**

| | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|
| Gun mounted on Buffington steel field carriage (light), No. 17, with old spiral spring brakes. De Bange gas-check. Cannon friction primers (experimental), with modified priming, March, 1890. Fired from platform on fort wall. | |
| Aimed at left edge of 3,000-yards target...... | Struck water at about 4,000 yards; was not observed in time to judge with certainty whether or not it exploded. |
| | Struck water at about 4,000 yards; burst on striking. Time of flight, 15 seconds. |
| | Struck water at about 4,000 yards; burst on striking. Time of flight, 14½ seconds. |
| | Gun hung fire, caused by eroded condition of vent piece. Struck water at about 4,500 yards; bursting doubtful. Time of flight, 17½ seconds. |
| Aimed to the right of 1-mile target .............. | Struck water at 3,000 yards; burst on striking. Time of flight, 9½ seconds. |
| Fired at 3,000-yards target ........................ | Struck 40 feet behind 3,000-yards target; burst on striking ground. Time of flight, 8¾ seconds. |
| Fired into seacoast butt, left section; to be recovered. | Frankford Arsenal percussion plunger. |
| | Modified Danish percussion plunger. |
| Shell recovered, but fuses destroyed to such an extent by impact that no information can be gained from them.<br>Gun sighted by Lieut. W. W. Gibson, Ordnance Department. Fall of projectile observed by Lieut. O. M. Lissak, Ordnance Department.<br>Firing conducted by the proof officer. | |

*Record of firing with 3.2-inch B. L. rifle (steel), No. 18, West*

[Object of firing, to test Frankford Arsenal

| Date. | | No. of fire. | Powder. | | Projectile. | | Elevation. | Fuse cut— | Fuse marked. | Recoil. | Wind, strength, and direction. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight | Kind. | Weight | | | | | |
| 1890. | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ′ | *Secs.* | | *Feet.* | |
| Nov. 19 | A. M. | 1407 | Du Pont's I. K. H. Lot 1. Density, 1.725. Granulation, 2050. | 3 12 | Shell (lot 279), Frankford Arsenal combination fuse (modified Danish). | 12 0<br>*5<br>†1 0<br>13 5 | 2 00 | 2 | ‡B | 10 | From front and right, 13 miles an hour. |
| Nov. 19 | | 1408 | | 3 12 | | 12 0<br>*5<br>†1 0<br>13 5 | 2 00 | 2 | §A | 10 | |

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* Rifle powder, bursting charge.

† Fuse.

‡ Fuse "B," modified Danish percussion plunger.

§ Fuse "A," Frankford Arsenal percussion plunger.

*Point Foundry, at Sandy Hook, N. J., November 19, 1890.*

**combination fuses (modified Danish).]**

| | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data, |
|---|---|
| Gun mounted on Buffington steel field carriage (light), No. 17, with old spiral-spring brakes. De Bange gas-check. Cannon friction primers (experimental), with modified priming, March. 1890. | |
| Fired down the beach. Aimed to the left of 1-mile target. | Four retaining strips left on igniter; others removed. Burst on striking ground. Time to striking ground, 5 seconds. This fuse had previously been bored to 10 seconds. |
| | Four retaining strips left on igniter; others removed. Burst on striking ground. Time to striking ground, 5 seconds. |
| Fall of projectile and time of flight observed by Lieut. W. W. Gibson, Ordnance Department.<br>Firing conducted by Capt. D. A. Lyle, Ordnance Department, assistant proof officer. | |

### *Record of firing with 3.2-inch B. L. rifle (steel), No. 18, West*

[Object of firing, trial of Frankford Arsenal combination fuse (modified Danish)

| Date. | | No. of series. | No. of fire. | Powder. | | Projectile. | | Elevation. | Fuse marked | Fuse set at— | Recoil. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Kind. | Weight. | Kind. | Weight. | | | | |
| 1890. | | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ′ | | *Secs.* | *Feet.* |
| Dec. 18 | P. M. | 11 | 1441 | Du Pont's I. K. H. Lot 16. Density, 1.725. Granulation, 2,524. | 3 12 | Shell (lot 279), with Frankford Arsenal combination fuse (modified Danish). | 12 0<br>*5<br>†1 0<br>13 5 | 8 35 | ‡A | 5 | 9 |
| Dec. 18 | | 12 | 1442 | | 3 12 | | 12 1<br>*6<br>†1 0<br>13 7 | 4 00 | §B | 3 | 10 |

* Rifle powder, bursting charge.
† Fuse.
‡ "A," Frankford Arsenal percussion plunger.
§ "B," modified Danish percussion plunger.

### *Record of firing with 3.6-inch B. L. field rifle (steel), No. 1,*

[Object of firing, to test Frankford Arsenal combination

| Date. | | No. of series. | No. of fire. | Powder. | | Projectile. | | Elevation. | Fuse marked. | Fuse set at— | Recoil. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Kind. | Weight. | Kind. | Weight. | | | | |
| 1800. | | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ′ | | *Secs.* | *Feet.* |
| Dec. 18 | P. M. | ...... | 167 | Du Pont's I. K. H. Lot 16. Density 1.725. Granulation, 2,524 | 4 0 | Shell (banded), experimental. Lot 249. | 19 1<br>15 sand.<br>20 0 | 10 0 | ...... | ...... | 11 |
| Dec. 18 | | 13 | 168 | | 4 0 | Shell (banded) experimental. Lot 249, with Frankford Arsenal combination fuse (modified Danish) in housing. | 20 7 | 10 0 | *A | 5 | 12 |
| Dec. 18 | | 14 | 169 | | 4 0 | | 20 0 | 10 0 | †B | 3 | 12 |

* "A," Frankford Arsenal percussion plunger.
† "B," Modified Danish percussion plunger.

*Point Foundry, at Sandy Hook, N. J., December 18, 1890.*

**with modified primer for igniting time train and with quick match inserted.]**

| Wind, strength and direction. | Time of flight. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|
| | | Gun mounted on carriage for 3-inch gun (altered muzzle loader), with old spiral-spring brakes. De Bange gas-check. Cannon friction primers (experimental), with modified priming, March, 1890. | |
| Wind from rear, 20 miles an hour. | *Secs.*<br>...... | Fired to sea ........ | Shell did not burst. |
| | 4½ | Aimed between 1 mile and 3,000-yard targets. | Shell burst. |
| | | Firing conducted by the proof officer. | |

*Watervliet Arsenal, at Sandy Hook, N. J., December 18, 1890.*

**fuses (modified Danish), fired in housing and recovered.]**

| Wind, stren'th and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|
| | Gun mounted on Buffington steel field carriage, No. 4. Spiral-spring brakes, clevis attachment. De Bange gas-check. Cannon friction primers (experimental), with modified priming, March 1890. | |
| From rear, 20 miles an hour. | Fired into sand butt, section 1.......... | Sighting shot.<br>Rear plunger removed before firing. On firing front plunger had operated, exploding percussion composition, brass covering of plunger forced into vents surrounding steel point, closing them. Lead cylinder of plunger driven forward into point. Time composition not ignited.<br>Rear plunger removed before firing. On firing front plunger had operated, exploding percussion composition; brass covering of plunger forced into vents surrounding steel point, partially closing them. Lead cylinder of plunger driven forward into point. Time train ignited and consumed. |
| | Firing conducted by the proof officer. | |

*Record of firing with 3.2-inch B. L. rifle (steel), No. 26,*

[Object of firing, test of Frankford Arsenal combina

| Date. | | No. of series. | No. of fire. | Powder. Kind. | Powder. Weight. | Projectile. Kind. | Projectile. Weight. | Elevation. | Fuse marked. | Recoil. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1891. | | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ′ | | *Feet.* |
| Jan. 6 | P. M. | 13 | 68 | Du Pont's I. K. H. Lot 16. Density, 1.725. Granulation, 2,524. | 3 12 | Service shell (lot 298) altered to receive Frankford Arsenal combination fuse (modified Danish), pattern of December, 1890. | 12 ⅜<br>*4⅝<br>†1 0<br>13 5 | 5 0 | A | 10 |
| Jan. 6 | | 14 | 70 | | 3 12 | | 12 ⅜<br>*4⅝<br>†1 0<br>13 5 | 5 0 | ‡A | 10 |
| Jan. 6 | | 15 | 71 | | 3 12 | | 12 ⅜<br>*4⅝<br>†1 0<br>13 5 | 5 0 | §B | 10 |
| Jan. 6 | | 16 | 72 | | 3 12 | | 12 ⅜<br>*4⅝<br>†1 0<br>13 5 | 8 0 | ‡A | 10 |

* Rifle powder. bursting charge.
† Fuse.
‡ Fuse "A," Frankford Arsenal percussion plunger.
§ Fuse "B," modified Danish percussion plunger.

(216–'91.)

*Record of firing with 3.2-inch B. L. rifle (steel),*

[Object of firing, to test Frankford

| Date. | | No. of series. | No. of fire. | Powder. Kind. | Powder. Weight. | Projectile. Kind. | Projectile. Weight. | Elevation. | Fuse marked. | Fuse set at — | Recoil. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1891. | | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ′ | | *Secs.* | *Feet.* |
| Feb. 27 | P. M. | 17 | 1534 | Du Pont's I. K. H. Lot 16. Density, 1.725. Granulation, 2,524. | 3 12 | Service shell (lot 303) altered to receive Frankford Arsenal combination fuse. | 12 1<br>*5<br>†1 0<br>13 6 | 5 00 | A | 3 | ........ |
| Feb. 27 | | 18 | 1540 | | 3 12 | | 12 0½<br>*5<br>†1 0<br>18 5½ | 5 00 | A | 5 | 9 |
| Feb. 27 | | 19 | 1541 | | 3 12 | | 12 1<br>*5<br>†1 0<br>13 6 | 5 00 | A | 5 | 10 |
| Feb. 27 | | 20 | 1542 | | 3 12 | | 12 1<br>*5<br>†1 0<br>13 6 | 3 00 | A | 3 | 10 |

* Rifle powder, bursting charge.
† Fuse.

*Watervliet Arsenal, at Sandy Hook, N. J., January 6, 1891.*

**tion fuse (modified Danish), pattern of December, 1890.]**

| Wind, strength and direction. | Fuse | | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|---|
| | Set at — | Burst at — | | |
| | | | Gun mounted on Buffington steel field carriage (light), No. 17. Wheels of carriage lashed to trail by rope. Cannon friction primers (experimental), with modified priming, March, 1890. | |
| | *Secs.* | *Secs.* | | |
| From right and rear, 23 miles an hour. | 5 | 8 | | |
| | 8 | 10¾ | | |
| | 8 | ...... | Fired to sea ........................ | Did not burst. Time to striking water 12¾ seconds. |
| | 8 | 11¼ | | |
| | | | Firing conducted by the proof officer. | |

*No. 18, at Sandy Hook, N. J., February 27, 1891.*

**Arsenal combination fuses, 24 seconds.]**

| Wind, strength and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|
| | Gun mounted on experimental steel carriage. Riveted flange modified at Watervliet Arsenal. Cannon friction primers, model 1887. | |
| From rear, 24 miles an hour. | .................................... | Burst. Time of flight, 4¾ seconds. |
| | .................................... | Struck ground 500 yards beyond 1-mile target. Did not burst. |
| | .................................... | Struck in the water. Did not burst. |
| | .................................... | Struck in the water. Did not burst. |
| | Firing conducted by Lieut. W. W. Gibson, O. D., assistant proof officer. | |

*Record of firing with 3.2-inch B. L. rifle (steel), No. 26,*

[Object of firing, to test Frankford

| Date. | | No. of series. | No. of fire. | Powder. | | Projectile. | | Elevation. |
|---|---|---|---|---|---|---|---|---|
| | | | | Kind. | Weight. | Kind. | Weight. | |
| 1891.<br>Mar. 26 | P. M.... | 22 | 154 | Du Pont's I.K,H. Lot 16. Density, 1.725. Granulation, 2,524. | *Lbs. Oz.*<br>3 12 | Service shell (lot 303) altered to receive Frankford Arsenal combination fuse. | *Lbs. Oz.*<br>12 1<br>*5<br>†1<br>13 6 | ° '<br>10 00 |

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* Rifle powder, bursting charge.

† Fuse.

(2044-'91.)

*Watervliet Arsenal, at Sandy Hook, N. J., March 26, 1891.*

**Arsenal combination fuse, 24 seconds.]**

| Fuse marked | Fuse cut— | Recoil. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|---|
| | | | Gun mounted on Buffington steel field carriage (light), No. 17; bow-spring brakes. Cannon friction primers, model 1887. | |
| A | *Secs.* 5 | *Feet.* 10 | Fired to sea........................ | Second pin placed through the body and base of the cone. Did not burst. |
| | | | Firing conducted by Lieut. C. B. Wheeler, O. D., assistant proof officer. | |

*Record of firing with 3.6-inch B. L. field rifle (steel), No. 1,*

[Object of firing, to ascertain cause of prema

| Date. | | No. of series. | No. of fire. | Powder. | | Projectile. | | Elevation. | Fuse cut at— | Recoil. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Kind. | Weight. | Kind. | Weight. | | | |
| | | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ′ | *Secs.* | *Feet.* |
| 1891.<br>Mar. 10 | A. M. | ...... | 226 | Du Pont's I. K. H. Lot 16. Density, 1.725. Granulation, 2,524. | 4 12 | Shell (banded), experimental. Lot 249. | 19 2<br>14 sand.<br>20* 0 | 0 10 | ........ | 15 |
| Mar. 10 | | 15 | 227 | | 4 12 | Shell (lot 249) fitted with housing for fuse. | *19 15½ | 0 10 | 5 | 14 |

* With fuse.

*Record of firing with 3.2-inch B. L. field rifle (steel), No. 26,*

[Object of firing, to test Frankford Arsenal

| Date. | | No. of fire. | Powder. | | Projectile. | | Elevation. | Fuse marked. | Fuse cut at— |
|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | | |
| | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ′ | | *Secs.* |
| 1891.<br>May 6 | P. M. ....... | 232 | Du Pont's I. K. H. Lot 27. Density, 1.725. Granulation, 2,605. | 3 12 | Service shell (lot 303) altered to receive Frankford Arsenal combination fuse. | 12 1<br>*5<br>†1 0<br>13 6 | 10 0 | B | 5 |
| May 6 | | 233 | | 3 12 | | 12 0½<br>*5<br>†1 0<br>13 5½ | 6 0 | B | 3 |
| May 6 | | 234 | | 3 12 | | 12 0<br>*5<br>†1 0<br>13 5 | 6 0 | B | 3 |

* Rifle powder, bursting charge. † Fuse.

*Watervleit Arsenal, at Sandy Hook, N. J., March 10, 1891.*

**ture explosion of point combination fuse.]**

| Wind, strength and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|
| | Gun mounted on Buffington steel field carriage No. 4. Old spiral-spring brakes. Cannon friction primers, model 1887. | |
| From front and right, 20 miles an hour. | Fired into sand butt, section 4 | Sighting shot.<br>Rear plunger removed before firing. Fuse recovered. Spindle broken where perforated, by flame passages. Spindle, cap, and cone (around which tube with time composition was wound) found separated from body of fuse. Composition in tube ignited. Composition in body not ignited. |
| | Gun sighted by Lieut. O. M. Lissak, O. D. Firing conducted by the proof officer. | |

*Watervliet Arsenal, at Sandy Hook, N. J., May 6, 1891.*

**combination fuses, received May 5, 1891.]**

| | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|
| Gun mounted on Buffington steel field carriage (light), No. 17, with old spiral-spring brakes. Cannon friction primers, model 1887. | |
| Fired to sea | Fuse without paper strip. Burst. Sound heard in 13 seconds.<br>Paper strip removed from fuse. Time to striking water, 10 seconds. Did not burst.<br>Paper partially stripped off, but remainder of paper strip was not removed. Burst in 5 seconds. |
| Firing conducted by Lieut. W. W. Gibson, O. D., assistant proof officer.<br>Present, Maj. G. W. McKee, O. D. | |

*Record of firing with 3.2-inch B. L. rifle (steel), No. 18, West*

[Object of firing, trial of Frankford Arsenal combination fuse (modified Danish)

| Date. | | No. of series. | No. of fire. | Powder. | | Projectile. | | Elevation. | Fuse marked | Fuse set at — | Recoil. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Kind. | Weight. | Kind. | Weight. | | | | |
| 1890. | | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ′ | | *Secs.* | *Feet.* |
| Dec. 18 | P. M. | 11 | 1441 | Du Pont's I. K. H. Lot 16. Density, 1.725. Granulation, 2,524. | 3 12 | Shell (lot 279), with Frankford Arsenal combination fuse (modified Danish). | 12 0<br>*5<br>†1 0<br>13 5 | 8 35 | ‡A | 5 | 9 |
| Dec. 18 | | 12 | 1442 | | 3 12 | | 12 1<br>*6<br>†1 0<br>13 7 | 4 00 | §B | 3 | 10 |

* Rifle powder, bursting charge.
† Fuse.
‡ "A," Frankford Arsenal percussion plunger.
§ "B," modified Danish percussion plunger.

*Record of firing with 3.6-inch B. L. field rifle (steel), No. 1,*

[Object of firing, to test Frankford Arsenal combination

| Date. | | No. of series. | No. of fire. | Powder. | | Projectile. | | Elevation. | Fuse marked. | Fuse set at— | Recoil. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Kind. | Weight. | Kind. | Weight. | | | | |
| 1890. | | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ′ | | *Secs.* | *Feet.* |
| Dec. 18 | P. M. | ...... | 167 | Du Pont's I. K. H. Lot 16. Density 1.725. Granulation, 2,524 | 4 0 | Shell (banded), experimental. Lot 249. | 19 1<br>15 sand.<br>20 0 | 10 0 | ...... | ...... | 11 |
| Dec. 18 | | 13 | 168 | | 4 0 | Shell (banded) experimental. Lot 249, with Frankford Arsenal combination fuse (modified Danish) in housing. | 20 7 | 10 0 | *A | 5 | 12 |
| Dec. 18 | | 14 | 169 | | 4 0 | | 20 0 | 10 0 | †B | 3 | 12 |

* "A," Frankford Arsenal percussion plunger.
† "B," Modified Danish percussion plunger.

*Point Foundry, at Sandy Hook, N. J., December 18, 1890.*

**with modified primer for igniting time train and with quick match inserted.]**

| Wind, strength and direction. | Time of flight. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|
| | *Secs.* | Gun mounted on carriage for 3-inch gun (altered muzzle loader), with old spiral-spring brakes. De Bange gas-check. Cannon friction primers (experimental), with modified priming, March, 1890. | |
| Wind from rear, 20 miles an hour. | ...... | Fired to sea.................................... | Shell did not burst. |
| | 4½ | Aimed between 1 mile and 3,000-yard targets. | Shell burst. |
| | | Firing conducted by the proof officer. | |

*Watervliet Arsenal, at Sandy Hook, N. J., December 18, 1890.*

**fuses (modified Danish), fired in housing and recovered.]**

| Wind, stren'th and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|
| | Gun mounted on Buffington steel field carriage, No. 4. Spiral-spring brakes, clevis attachment. De Bange gas-check. Cannon friction primers (experimental), with modified priming, March 1890. | |
| From rear, 20 miles an hour. | Fired into sand butt, section 1.......... | Sighting shot.<br>Rear plunger removed before firing. On firing front plunger had operated, exploding percussion composition, brass covering of plunger forced into vents surrounding steel point, closing them. Lead cylinder of plunger driven forward into point. Time composition not ignited.<br>Rear plunger removed before firing. On firing front plunger had operated, exploding percussion composition; brass covering of plunger forced into vents surrounding steel point, partially closing them. Lead cylinder of plunger driven forward into point. Time train ignited and consumed. |
| | Firing conducted by the proof officer. | |

*Record of firing with 3.2-inch B. L. rifle (steel), No. 26,*

[Object of firing, test of Frankford Arsenal combina

| Date. | | No. of series. | No. of fire. | Powder. | | Projectile. | | Elevation. | Fuse marked. | Recoil. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1891. | | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ' | | *Feet.* |
| Jan. 6 | P. M. | 13 | 68 | Du Pont's I. K. H. Lot 16. Density, 1.725. Granulation, 2,524. | 3 12 | Service shell (lot 298) altered to receive Frankford Arsenal combination fuse (modified Danish), pattern of December, 1890. | 12 ½<br>*4½<br>†1 0<br>13 5 | 5 0 | A | 10 |
| Jan. 6 | | 14 | 70 | | 3 12 | | 12 ½<br>*4½<br>†1 0<br>13 5 | 5 0 | ‡A | 10 |
| Jan. 6 | | 15 | 71 | | 3 12 | | 12 ½<br>*4½<br>†1 0<br>13 5 | 5 0 | §B | 10 |
| Jan. 6 | | 16 | 72 | | 3 12 | | 12 ½<br>*4½<br>†1 0<br>13 5 | 8 0 | ‡A | 10 |

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* Rifle powder. bursting charge.

† Fuse.

‡ Fuse "A," Frankford Arsenal percussion plunger.

§ Fuse "B," modified Danish percussion plunger.

(216-'91.)

*Record of firing with 3.2-inch B. L. rifle (steel),*

[Object of firing, to test Frankford

| Date. | | No. of series. | No. of fire. | Powder. | | Projectile. | | Elevation. | Fuse marked. | Fuse set at — | Recoil. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Kind. | Weight. | Kind. | Weight. | | | | |
| 1891. | | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ' | | *Secs.* | *Feet.* |
| Feb. 27 | P. M. | 17 | 1534 | Du Pont's I. K. H. Lot 16. Density, 1.725. Granulation, 2.524. | 3 12 | Service shell (lot 303) altered to receive Frankford Arsenal combination fuse. | 12 1<br>*5<br>†1 0<br>13 6 | 5 00 | A | 3 | ........ |
| Feb. 27 | | 18 | 1540 | | 3 12 | | 12 0½<br>*5<br>†1 0<br>13 5½ | 5 00 | A | 5 | 9 |
| Feb. 27 | | 19 | 1541 | | 3 12 | | 12 1<br>*5<br>†1 0<br>13 6 | 5 00 | A | 5 | 10 |
| Feb. 27 | | 20 | 1542 | | 3 12 | | 12 1<br>*5<br>†1 0<br>13 6 | 3 00 | A | 3 | 10 |

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* Rifle powder, bursting charge.

† Fuse.

*Watervliet Arsenal, at Sandy Hook, N. J., January 6, 1891.*

tion fuse (modified Danish), pattern of December, 1890.]

| Wind, strength and direction. | Fuse<br>Set at — | <br>Burst at — | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|---|
| | | | Gun mounted on Buffington steel field carriage (light), No. 17. Wheels of carriage lashed to trail by rope. Cannon friction primers (experimental), with modified priming, March, 1890. | |
| | *Secs.* | *Secs.* | | |
| From right and rear, 23 miles an hour. | 5 | 8 | | |
| | 8 | 10¾ | | |
| | 8 | ...... | Fired to sea | Did not burst. Time to striking water 12¾ seconds. |
| | 8 | 11½ | | |
| | | | Firing conducted by the proof officer. | |

*No. 18, at Sandy Hook, N. J., February 27, 1891.*

Arsenal combination fuses, 24 seconds.]

| Wind, strength and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|
| | Gun mounted on experimental steel carriage. Riveted flange modified at Watervliet Arsenal. Cannon friction primers, model 1887. | |
| From rear, 24 miles an hour. | .................................... | Burst. Time of flight, 4¾ seconds. |
| | .................................... | Struck ground 500 yards beyond 1-mile target. Did not burst. |
| | .................................... | Struck in the water. Did not burst. |
| | .................................... | Struck in the water. Did not burst. |
| | Firing conducted by Lieut. W. W. Gibson, O. D., assistant proof officer. | |

*Record of firing with 3.2-inch B. L. rifle (steel), No. 26,*

[Object of firing, to test Frankford

| Date. | | No. of series. | No. of fire. | Powder. | | Projectile. | | Elevation. |
|---|---|---|---|---|---|---|---|---|
| | | | | Kind. | Weight. | Kind. | Weight. | |
| | | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ′ |
| 1891.<br>Mar. 26 | P. M.... | 22 | 154 | Du Pont's I.K,H. Lot 16. Density, 1.725. Granulation, 2,524. | 3 12 | Service shell (lot 303) altered to receive Frankford Arsenal combination fuse. | 12 1<br>*5<br>†1 | 10 00 |
| | | | | | | | 13 6 | |

* Rifle powder, bursting charge.

† Fuse.

(2044–'91.)

*Watervliet Arsenal, at Sandy Hook, N. J., March 26, 1891.*

**Arsenal combination fuse, 24 seconds.]**

| Fuse marked | Fuse cut— | Recoil. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|---|
| | | | Gun mounted on Buffington steel field carriage (light), No. 17; bow-spring brakes. Cannon friction primers, model 1887. | |
| A | *Secs.* 5 | *Feet.* 10 | Fired to sea | Second pin placed through the body and base of the cone. Did not burst. |
| | | | Firing conducted by Lieut. C. B. Wheeler, O. D., assistant proof officer. | |

*Record of firing with 3.6-inch B. L. field rifle (steel), No. 1,*

**[Object of firing, to ascertain cause of prema**

| Date. | | No. of series. | No. of fire. | Powder. | | Projectile. | | Elevation. | Fuse cut at— | Recoil. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1891. | | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ′ | *Secs.* | *Feet.* |
| Mar. 10 | A. M. | ...... | 226 | Du Pont's I. K. H. Lot 16. Density, 1.725. Granulation, 2,524. | 4 12 | Shell (banded), experimental. Lot 249. | 19 2<br>14 sand.<br>20* 0 | 0 10 | ........ | 15 |
| Mar. 10 | | 15 | 227 | | 4 12 | Shell (lot 249) fitted with housing for fuse. | *19 15½ | 0 10 | 5 | 14 |

* With fuse.

*Record of firing with 3.2-inch B. L. field rifle (steel), No. 26,*

**[Object of firing, to test Frankford Arsenal**

| Date. | | No. of fire. | Powder. | | Projectile. | | Elevation. | Fuse marked. | Fuse cut at— |
|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1891. | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ′ | | *Secs.* |
| May 6 | P. M. ....... | 232 | Du Pont's I. K. H. Lot 27. Density, 1.725. Granulation, 2,605. | 3 12 | Service shell (lot 303) altered to receive Frankford Arsenal combination fuse. | 12 1<br>*5<br>†1 0<br>13 6 | 10 0 | B | 5 |
| May 6 | | 233 | | 3 12 | | 12 0½<br>*5<br>†1 0<br>13 5½ | 6 0 | B | 3 |
| May 6 | | 234 | | 3 12 | | 12 0<br>*5<br>†1 0<br>13 5 | 6 0 | B | 3 |

* Rifle powder, bursting charge. † Fuse.

*Watervleit Arsenal, at Sandy Hook, N. J., March 10, 1891.*

**ture explosion of point combination fuse.]**

| Wind, strength and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|
| | Gun mounted on Buffington steel field carriage No. 4. Old spiral-spring brakes. Cannon friction primers, model 1887. | |
| From front and right, 20 miles an hour. | Fired into sand butt, section 4......... | Sighting shot. |
| | | Rear plunger removed before firing. Fuse recovered. Spindle broken where perforated, by flame passages. Spindle, cap, and cone (around which tube with time composition was wound) found separated from body of fuse. Composition in tube ignited. Composition in body not ignited. |
| | Gun sighted by Lieut. O. M. Lissak, O. D.<br>Firing conducted by the proof officer. | |

*Watervliet Arsenal, at Sandy Hook, N. J., May 6, 1891.*

**combination fuses, received May 5, 1891.]**

| | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|
| Gun mounted on Buffington steel field carriage (light), No. 17, with old spiral-spring brakes. Cannon friction primers, model 1887. | |
| Fired to sea.................................. | Fuse without paper strip. Burst. Sound heard in 13 seconds. |
| | Paper strip removed from fuse. Time to striking water, 10 seconds. Did not burst. |
| | Paper partially stripped off, but remainder of paper strip was not removed. Burst in 5 seconds. |
| Firing conducted by Lieut. W. W. Gibson, O. D., assistant proof officer.<br>Present, Maj. G. W. McKee, O. D. | |

*Record of firing with 3.2-inch B. L. rifle (steel), No. 26,*

[Object of firing, to test Frankford Arsenal com-

| Date. | No. of fire. | Powder. | | Projectile. | | Fuse marked. | Fuse cut at— | Elevation. | Wind, strength and direction. |
|---|---|---|---|---|---|---|---|---|---|
| | | Kind. | Weight. | Kind. | Weight. | | | | |
| 1891. | | | *Lbs. Oz.* | | *Lbs. Oz.* | *No.* | *Inch.* | ° ′ | |
| July 7 | 269 | Du Pont's I. K. H. Lot 27. Density, 1.725. Granulation, 2,605. | 3 12 | Shell (lot 318) altered to receive Frankford Arsenal combination fuse. | 12 2<br>1 0 fuse.<br>6 powder.<br>13 8 | 1 | ½ | 10 0 | From left and front, 16 miles an hour. |
| July 7 | 270 | | 3 12 | | 12 0½<br>0½ charcoal.<br>1 0 fuse.<br>5 powder.<br>13 6 | 2 | ½ | 10 0 | |
| July 7 | 271 | | 3 12 | | 12 2<br>0½ charcoal.<br>1 0 fuse.<br>5 powder.<br>13 7½ | 3 | ½ | 10 0 | |
| July 7 | 272 | | 3 12 | | 12 2<br>0½ charcoal.<br>1 0 fuse.<br>5 powder.<br>13 7½ | 4 | ½ | 10 0 | |
| July 7 | 273 | | 3 12 | | 12 2<br>0½ charcoal.<br>1 0 fuse.<br>5 powder.<br>13 7½ | 5 | ½ | 10 0 | |
| July 7 | 274 | | 3 12 | | 12 2<br>0½ charcoal.<br>1 0 fuse.<br>5 powder.<br>13 7½ | 6 | ½ | 10 0 | |
| July 7 | 275 | | 3 13 | | 12 1<br>0½ charcoal.<br>1 0 fuse.<br>5 powder.<br>13 6½ | 7 | ½ | 10 0 | |

*Watervliet Arsenal, at Sandy Hook, N. J., July 7, 1891.*

**bination fuse (15 seconds), model May, 1891.]**

| Time of flight. | | | | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|---|---|
| First watch, Capt. Baker. | Second watch, Lieut. Gibson. | Third watch, Lieut. Wheeler. | Fourth watch, Mr. Gill. | | |
| | | | | Gun mounted on Buffington steel field carriage (light), No. 17. Spiral-spring brake on right wheel; spiral-spring brake-clevis attachment on left wheel. Cannon electric primers used in rounds 269 and 270. Cannon friction primers, model 1887. | |
| *Secs.*<br>1 | *Secs.*<br>1¾ | *Secs.*<br>1¼ | *Secs.*<br>1¼ | | Shell burst. |
| 1¼ | 1 | 1 | Lost. | | Shell burst. |
| Lost. | 0¾ | 0¾ | Lost. | | Shell burst. |
| 1¾ | 1⅛ | 0¾ | $1\frac{3}{10}$ | Fired to sea...................... | Shell burst. |
| 1¼ | 1⅛ | 0¾ | 1 | | Shell burst. |
| 1¼ | 1 | 0¾ | $0\frac{3}{10}$ | | Shell burst. |
| Lost. | 1 | 1 | 0¾ | | Shell burst. |
| | | | | Rounds 269 to 276, inclusive, fuses cut by Mr. Gill; rounds 277 to 280, inclusive, fuses cut by Lieut. Gibson, Ordnance Department; rounds 281 to 290, inclusive, fuses cut by Corpl. Alward, Ordnance Detachment. Left-hand spiral, 4 vents. | |

*Record of firing with 3.2-inch B. L. rifle (steel), No. 1,*

| Date. | No. of fire. | Powder. | | Projectile. | | Fuse marked | Fuse cut at— | Elevation. | Wind, strength and direction. |
|---|---|---|---|---|---|---|---|---|---|
| | | Kind. | Weight. | Kind. | Weight. | | | | |
| 1891. | | | *Lbs. Oz.* | | *Lbs. Oz.* | *No.* | *Inch.* | ° ' | |
| July 7 | 276 | Du Pont's I. K. H. Lot 27. Density, 1.725. Granulation, 2.605. | 3 12 | Shell (lot 318) altered to receive Frankford Arsenal combination fuse. | 12 2<br>0½ charcoal.<br>1 0 fuse.<br>5 powder.<br>13 7½ | 8 | ½ | 10 0 | From left and front, 16 miles an hour. |
| July 7 | 277 | | 3 12 | | 11 15<br>0½ charcoal.<br>5 powder.<br>1 0 fuse.<br>13 4½ | 9 | ½ | 10 0 | |
| July 7 | 278 | | 3 12 | | 11 15<br>0½ charcoal.<br>1 0 fuse.<br>5 powder.<br>13 4½ | 10 | ½ | 10 0 | |
| July 7 | 279 | | 3 12 | | 11 12<br>0½ charcoal.<br>1 0 fuse.<br>5 powder.<br>13 1½ | 11 | ½ | 10 0 | |
| July 7 | 280 | | 3 12 | | 12 2<br>0½ charcoal.<br>1 0 fuse.<br>5 powder.<br>13 7½ | 12 | ½ | 10 0 | |
| July 7 | 281 | | 3 12 | | 12 1<br>0½ charcoal.<br>1 0 fuse.<br>5 powder.<br>13 6½ | 13 | ½ | 10 0 | |
| July 7 | 282 | | 3 12 | | 12 1<br>0½ charcoal.<br>1 0 fuse.<br>5 powder.<br>13 6½ | 14 | ½ | 10 0 | |
| July 7 | 283 | | 3 12 | | 12 1<br>0½ charcoal.<br>1 0 fuse.<br>5 powder.<br>13 6½ | 15 | ½ | 10 0 | |
| July 7 | 284 | | 3 12 | | 12 2<br>0½ charcoal.<br>1 0 fuse.<br>5 powder.<br>13 7½ | 16 | ½ | 10 0 | |
| July 7 | 285 | | 3 12 | | 12 0<br>0½ charcoal.<br>1 0 fuse.<br>5 powder.<br>13 5½ | 17 | ½ | 10 0 | |

*Watervliet Arsenal, at Sandy Hook, N. J., July 7, 1891.*

| Time of flight. | | | | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|---|---|
| First watch, Capt. Baker. | Second watch, Lieut. Gibson. | Third watch, Lieut. Wheeler. | Fourth watch, Mr. Gill. | | |
| *Secs.* | *Secs.* | *Secs.* | *Secs.* | | |
| 1⅕ | 1⅕ | 1¼ | 1 | Fired to sea. Cannon friction primers, model 1887. Left-hand spiral, 4 vents. | Shell burst. |
| 1⅕ | 1⅕ | 0⅘ | 0 9/10 | | Shell burst. |
| Lost. | 1⅕ | 1 | 9 9/10 | | Gun hung fire. Shell burst. |
| 1 | 1⅕ | 0⅘ | 1 | | Two cartridges too large to enter chamber of gun. Shell burst. |
| 1 | 1 | 1 | 1 | | Shell burst. |
| 1 | 1⅕ | 1 | Lost. | | Shell burst. |
| 0⅘ | 1 | 0⅘ | 0 8/10 | | Shell burst. |
| 0⅘ | 1 | 1 | 0⅘ | Fired to sea. First ⅜ inch on fuse corresponds to 0.95 inch, chronoscope time; after that ⅜ of an inch is equal to 1 second. 2¼ inches corresponds to 4 seconds, chronoscope time. Left-hand spiral, 4 vents. | Shell burst. |
| 0⅘ | 1⅕ | 1 | 0⅘ | | First primer failed to ignite charge. Head of primer blown off; base intact. Shell burst. |
| 1 | 1⅕ | 1 | Lost. | | Shell burst. |

*Record of firing with 3.2-inch B. L. rifle (steel), No. 1; Watervliet*

| Date. | No. of fire. | Powder. | | | Projectile. | | | Fuse marked. | Fuse cut at— | Elevation. | | Wind, strength and direction. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Kind. | Weight. | | Kind. | Weight. | | | | | | |
| 1891. | | | *Lbs.* | *Oz.* | | *Lbs.* | *Oz.* | *No.* | *Inch.* | ° | ′ | |
| July 7 | 286 | Du Pont's I. K. H. Lot 27. Density, 1.725. Granulation, 2,605. | 8 | 12 | Shell (lot 318) altered to receive Frankford Arsenal combination fuse. | 12<br><br>1<br><br>13 | 0<br>0⅛ charcoal.<br>0 fuse.<br>5 powder.<br>5⅛ | 18 | ⅛ | 10 | 0 | From left and front, 16 miles an hour. |
| July 7 | 287 | | 8 | 12 | | 12<br><br>1<br><br>13 | 1<br>0⅛ charcoal.<br>0 fuse.<br>5 powder.<br>6⅛ | 19 | ⅛ | 10 | 0 | |
| July 7 | 288 | | 8 | 12 | | 12<br><br>1<br><br>13 | 1<br>0⅛ charcoal.<br>0 fuse.<br>5 powder.<br>6⅛ | 20 | ⅛ | 10 | 0 | |
| July 7 | 289 | | 8 | 12 | | 12<br><br>1<br><br>13 | 0<br>0⅛ charcoal.<br>0 fuse.<br>5 powder.<br>5⅛ | 21 | ⅛ | 8 | 0 | |
| July 7 | 290 | | 8 | 12 | | 12<br><br>1<br><br>13 | 2<br>0⅛ charcoal.<br>0 fuse.<br>5 powder.<br>7⅛ | 22 | ⅛ | 3 | 0 | |

*Arsenal, at Sandy Hook, N. J., July 7, 1891*—Continued.

| Time of flight. | | | | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|---|---|
| First watch, Capt. Baker. | Second watch, Lieut. Gibson. | Third watch, Lieut. Wheeler. | Fourth watch, Mr. Gill. | | |
| *Secs.* | *Secs.* | *Secs.* | *Secs.* | | |
| Lost. | 1 | 1 | Lost. | Fired to sea. First ½ inch on fuse corresponds to 0.95 inch, chronoscope time; after that ½ of an inch is equal to 1 second. 2¾ inches corresponds to 4 seconds, chronoscope time. Left-hand spiral, 4 vents. | Shell burst. |
| 0¾ | 1 | Lost. | 1 | | Shell burst. |
| 1½ | 1½ | ........ | 1 | | Shell burst. |
| 5 | 4½ | ........ | 4 | Fired at mile target. | Bonnet of fuse removed to permit of boring. Shell burst 25 yards beyond mile target. |
| Lost. | 4½ | ........ | Lost. | | Bonnet of fuse removed to permit of boring. Burst 30 yards in front of mile target. |

*Record of firing with 3.2-inch B. L. rifle (steel), No. 26,*

| Date. | No. of fire. | Powder. |  | Projectile. |  | Fuse marked. | Fuse cut at— | Elevation. | Wind, strength and direction. |
|---|---|---|---|---|---|---|---|---|---|
|  |  | Kind. | Weight. | Kind. | Weight. |  |  |  |  |
| 1891. |  |  | *Lbs. Oz.* |  | *Lbs. Oz.* | *No.* | *Inches.* | ° ′ |  |
| July 8 | 291 | Du Pont's I. K. H. Lot 27. Density, 1.725. Granulation, 2,605. | 3 12 | Shell (lot 318) altered to receive Frankford Arsenal combination fuse. | 12 2<br>0½ charcoal<br>1 0 fuse.<br>5 powder.<br>13 7½ | 23 | 2¾ | 3 0 | From right and rear, 9 miles an hour. |
| July 8 | 292 |  | 3 12 |  | 12 1<br>0½ charcoal<br>1 0 fuse.<br>5 powder.<br>13 6½ | 24 | 2¾ | 3 0 |  |
| July 8 | 293 |  | 3 12 |  | 11 15<br>0½ charcoal<br>1 0 fuse.<br>5 powder.<br>13 4½ | 25 | 2¾ | 3 0 |  |
| July 8 | 294 |  | 3 12 |  | 12 2<br>0½ charcoal<br>1 0 fuse.<br>5 powder.<br>13 7½ | 26 | 2¾ | 3 0 |  |
| July 8 | 295 |  | 3 12 |  | 12 1<br>0½ charcoal<br>1 0 fuse.<br>5 powder.<br>13 6½ | 27 | 2¾ | 3 0 |  |
| July 8 | 296 |  | 3 12 |  | 12 2<br>0½ charcoal<br>1 0 fuse.<br>5 powder.<br>13 7½ | 28 | 2¾ | 3 0 |  |
| July 8 | 297 |  | 3 12 |  | 12 1<br>0½ charcoal<br>1 0 fuse.<br>5 powder.<br>13 6½ | 29 | 2¾ | 3 0 |  |
| July 8 | 298 |  | 3 12 |  | 12 2<br>0½ charcoal<br>1 0 fuse.<br>5 powder.<br>13 7½ | 30 | 2¾ | 3 0 |  |
| July 8 | 299 |  | 3 12 |  | 12 2<br>0½ charcoal<br>1 0 fuse.<br>5 powder.<br>13 7½ | 31 | 2¾ | 3 0 |  |
| July 8 | 300 |  | 3 12 |  | 12 1<br>0½ charcoal<br>5 powder.<br>1 0 fuse.<br>13 6½ | 32 | 2¾ | 3 0 |  |

*Watervliet Arsenal, at Sandy Hook, N. J., July 8, 1891.*

| Time of flight. | | | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|---|
| First watch, Capt. Baker. | Second watch, Lieut. Gibson. | Third watch, Mr. Gill. | | |
| *Secs.* | *Secs.* | *Secs.* | | |
| Lost. | 4⅕ | 4⅕ | Fired at 1-mile target. Bonnet of fuse removed to permit of boring. Fuses cut by Mr. Gill. Cannon friction primers, model 1887. Left hand spiral, 4 vents. | Shell burst 25 feet in rear of target. |
| 4 | 4⅕ | 3⅘ | | Shell burst 104 feet in front of target. |
| ........ | ........ | ........ | | Did not burst. |
| 4 | 4⅕ | Lost. | | Shell burst 245 feet in front of target. |
| 4 | 4⅕ | 3⅘ | | Shell burst 118 feet in front of target. |
| 4 | 4⅕ | 3⅘ | | Shell burst 66 feet in front of target. |
| 4 | 4⅕ | 4⅕ | | Shell burst 83 feet in front of target. |
| 4⅕ | 4⅕ | 3⅘ | | Shell burst 47 feet in front of target. |
| 4 | 4⅕ | 3⅘ | | Shell burst 44 feet in front of target. |
| 4⅕ | 4⅕ | 4 | | Shell burst 31 feet in rear of target. |

*Record of firing with 3.2-inch B. L. rifle (steel), No. 26, Watervliet*

| Date. | No. of fire. | Powder. |  | Projectile. |  | Fuse marked. | Fuse cut at— | Elevation. | Wind, strength and direction. |
|---|---|---|---|---|---|---|---|---|---|
|  |  | Kind. | Weight. | Kind. | Weight. |  |  |  |  |
| 1891. |  |  | *Lbs. Oz.* |  | *Lbs. Oz.* | *No.* | *Inches.* | ° ′ |  |
| July 8 | 301 | Du Pont's I. K. H. Lot 27. Density, 1.725. Granulation, 2,605. | 3 12 | Shell re-banded. | 12 15<br>9 sand.<br>13 8 | ....... | ....... | 5 25 | From right and rear, 9 miles an hour. |
| July 8 | 302 |  | 3 12 | Shell (lot 318) altered to receive Frankford Arsenal combination fuse. | 12 1<br>0½ charcoal<br>1 0 fuse.<br>5 powder.<br>13 6½ | 33 | 6½ | 6 0 |  |
| July 8 | 303 |  | 3 12 |  | 11 15<br>0½ charcoal<br>5 powder.<br>1 0 fuse.<br>13 4½ | 34 | 6½ | 8 0 |  |
| July 8 | 304 |  | 3 12 |  | 12 1<br>0½ charcoal<br>5 powder.<br>1 0 fuse.<br>13 6½ | 35 | 6½ | 7 0 |  |
| July 8 | 305 |  | 3 12 |  | 12 1<br>0½ charcoal<br>1 0 fuse.<br>5 powder.<br>13 6½ | 36 | 6 | 7 0 |  |
| July 8 | 306 |  | 3 12 |  | 12 0<br>0½ charcoal<br>1 0 fuse.<br>5 powder.<br>13 5½ | ....... | 5½ | 7 0 |  |
| July 8 | 307 |  | 3 12 |  | 12 1<br>0½ charcoal<br>1 0 fuse.<br>5 powder.<br>13 6½ | ....... | 5½ | 7 0 |  |

*Arsenal, at Sandy Hook, N. J., July 8, 1891*—Continued.

| Time of flight. | | | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|---|
| First watch, Capt. Baker. | Second watch, Lieut. Gibson. | Third watch, Mr. Gill. | | |
| *Secs.* | *Secs.* | *Secs.* | | |
| ........ | ........ | ........ | Fired at 3,000-yards target. Fuses cut by Corpl. Alward, Ordnance Detachment. Cannon primers (friction), model 1887. Left-hand spiral, 4 vents. | Sighting shot. First primer failed; head blown off; base intact. |
| ........ | ........ | ........ | | Shell burst on striking sand, about 600 yards in rear of target. |
| Lost. | 10½ | ........ | | Shell burst about 900 feet in rear of target. |
| 10 | 10 | ........ | | Shell burst 900 feet in rear of target. |
| 9½ | 9½ | ........ | | Shell burst 820 feet in rear of target. |
| 9 | 9½ | ........ | | Shell burst 400 feet in rear of target. First primer failed; head blown off; base intact. |
| 8½ | 8½ | ........ | | Shell burst 273 feet in rear of target. |
| | | | | Firing conducted by Lieut. W. W. Gibson, O. D., assistant proof officer. Present, Capt. F. Baker, O. D., and Mr. Gill. |

*Record of firing with 3.2-inch B. L. rifle (steel), No. 26, Watervliet*

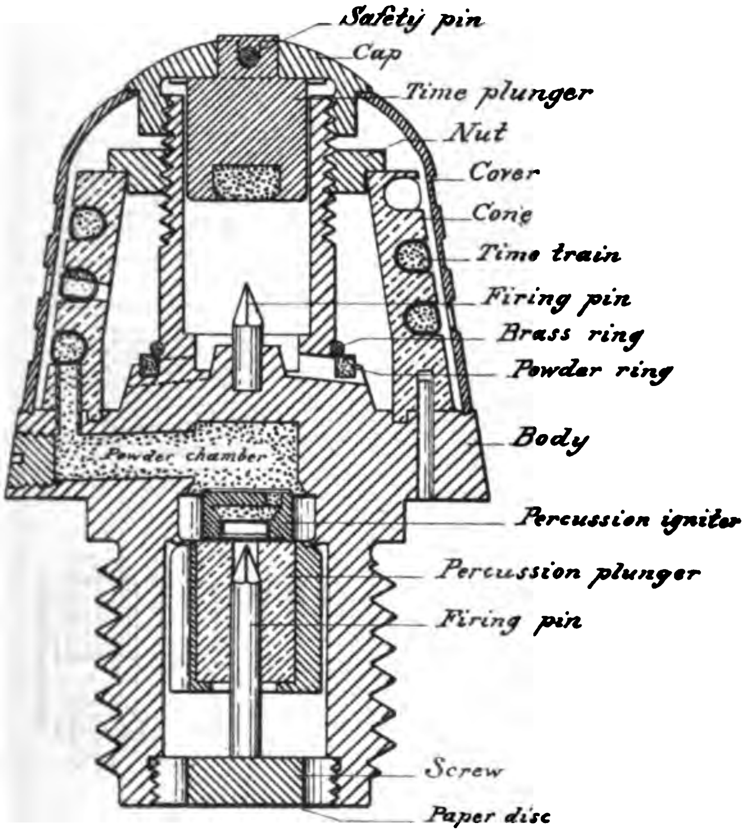
| Date. | No. of fire. | Powder. Kind. | Powder. Weight. | Projectile. Kind. | Projectile. Weight. | Fuse marked. | Fuse cut at— | Elevation. | | Wind, strength and direction. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1891. | | | *Lbs. Oz.* | | *Lbs. Oz.* | *No.* | *Inches.* | ° | ′ | |
| July 8 | 301 | Du Pont's I. K. H. Lot 27. Density, 1.725. Granulation, 2,605. | 3 12 | Shell re-banded. | 12 15<br>9 sand.<br>13 8 | ........ | ........ | 5 | 25 | From right and rear, 9 miles an hour. |
| July 8 | 302 | | 3 12 | Shell (lot 318) altered to receive Frankford Arsenal combination fuse. | 12 1<br>0⅛ charcoal<br>1 0 fuse.<br>5 powder.<br>13 6⅛ | 33 | 6⅛ | 6 | 0 | |
| July 8 | 303 | | 3 12 | | 11 15<br>0⅛ charcoal<br>5 powder.<br>1 0 fuse.<br>13 4⅛ | 34 | 6⅛ | 8 | 0 | |
| July 8 | 304 | | 3 12 | | 12 1<br>0⅛ charcoal<br>5 powder.<br>1 0 fuse.<br>13 6⅛ | 35 | 6⅛ | 7 | 0 | |
| July 8 | 305 | | 3 12 | | 12 1<br>0⅛ charcoal<br>1 0 fuse.<br>5 powder.<br>13 6⅛ | 36 | 6 | 7 | 0 | |
| July 8 | 306 | | 3 12 | | 12 0<br>0⅛ charcoal<br>1 0 fuse.<br>5 powder.<br>13 5⅛ | ........ | 5⅛ | 7 | 0 | |
| July 8 | 307 | | 3 12 | | 12 1<br>0⅛ charcoal<br>1 0 fuse.<br>5 powder.<br>13 6⅛ | ........ | 5⅛ | 7 | 0 | |

*Arsenal, at Sandy Hook, N. J., July 8, 1891*—Continued.

| Time of flight. | | | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|---|
| First watch, Capt. Baker. | Second watch, Lieut. Gibson. | Third watch, Mr. Gill. | | |
| *Secs.* | *Secs.* | *Secs.* | | |
| ....... | ....... | ....... | Fired at 3,000-yards target. Fuses cut by Corpl. Alward, Ordnance Detachment. Cannon primers (friction), model 1887. Left-hand spiral, 4 vents. | Sighting shot. First primer failed; head blown off; base intact. |
| ....... | ....... | ....... | | Shell burst on striking sand, about 600 yards in rear of target. |
| Lost. | 10⅓ | ....... | | Shell burst about 900 feet in rear of target. |
| 10 | 10 | ....... | | Shell burst 900 feet in rear of target. |
| 9⅓ | 9⅓ | ....... | | Shell burst 820 feet in rear of target. |
| 9 | 9½ | ....... | | Shell burst 400 feet in rear of target. First primer failed; head blown off; base intact. |
| 8⅓ | 8⅔ | ....... | | Shell burst 273 feet in rear of target. |
| | | | | Firing conducted by Lieut. W. W. Gibson, O. D., assistant proof officer. Present, Capt. F. Baker, O. D., and Mr. Gill. |

# The Frankford Arsenal Combination Fuze

MODEL OF MAY 1891



Frankford Arsenal
September 1891

Frank Baker
CAPTAIN OF ORDNANCE
COMMANDING

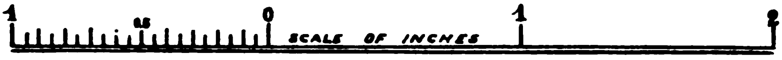


PLATE III.

FRANKFORD ARSENAL
September 1891
Frank Baker
Captain of Ordnance
Commanding

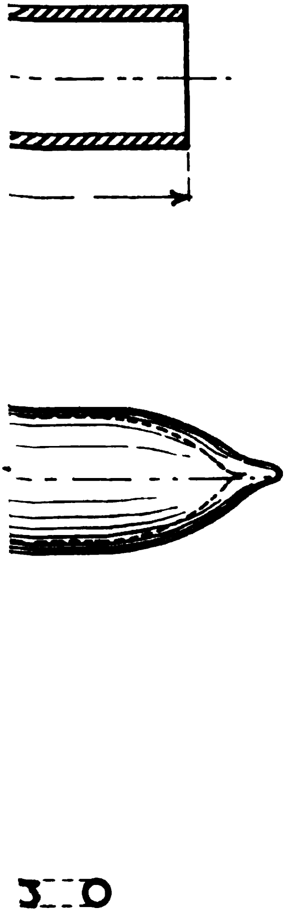
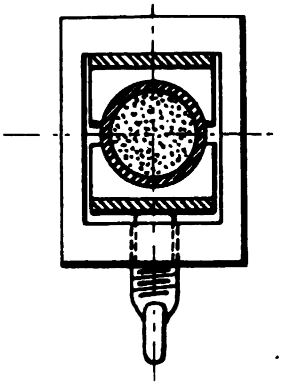


Fig. III
Section on A.B



1 2 3 4 INCHES

# APPENDIX 21.

## *SPECIFICATIONS GOVERNING THE MANUFACTURE AND INSPECTION OF CARRIAGES AND PARTS OF CARRIAGES FOR CANNON, PRESCRIBED BY THE ORDNANCE DEPARTMENT, U. S. ARMY.*

### 1. INSPECTION OF THE MANUFACTURE.

The manufacture shall be open to inspection in all its details by the officers and employés of the Ordnance Department assigned to duty for that purpose, and shall receive the approval of the inspector at the works, or such one of his assistants as he may designate, at all its stages.

### 2. INFORMATION AND ASSISTANCE TO BE GIVEN INSPECTORS.

That the requirements of paragraph 1 may be carried out the manufacturers shall, before commencing the work under any order or contract, inform the inspector of their general plans, and during the progress of the work they shall inform him of the chemical composition of each and every ingot or casting which they propose to use, together with a statement of its casting, size, and condition; they shall inform him, or such of his assistants as he may designate, of the time at which each operation connected, either directly or indirectly, with the manufacture is to take place, and shall give him such notification as may be required to insure his witnessing any particular part of an operation which he may specify; they shall furnish him with a copy of the results of all chemical analyses and mechanical tests made at their works in any way connected with the material to be furnished; they shall provide all necessary labor and allow the use of the necessary tools and implements for the assistance of the inspector and his assistants in the performance of any of their duties, and they shall, when required, provide within their works suitable and satisfactory office room for records, drawings, books, etc., which may be used exclusively by the inspector and his assistants.

### 3. DRAWINGS AND BLANK FORMS.

All carriages or parts of carriages shall be constructed from drawings approved by the Chief of Ordnance or by the inspector, and no deviations therefrom will be permitted without the authority of the approving officer; prints, in duplicate, of the alterations allowed will be furnished the inspector. When general drawings only are furnished by the Chief of Ordnance the manufacturers shall submit each detailed drawing or modification thereof to the inspector for his approval, and shall furnish him with prints, in duplicate, of all such approved drawings. Upon completion of the work the manufacturers shall furnish the Chief of Ordnance with a full set of tracings upon linen of the general and detailed drawings of the carriages as constructed in so far as they differ from, or are not included in, the drawings furnished by the Chief of Ordnance.

All drawings required above and used in the prosecution of the work and all blank forms required to facilitate the transaction of business between the inspector and the manufacturers shall be furnished by the manufacturers without charge. The drawings furnished by the Chief of Ordnance will be considered confidential and for the prosecution of Government work only.

### 4. CHANGES IN DRAWINGS.

The dimensions shown on the drawings accompanying contracts shall always be subject to such changes as the Chief of Ordnance may deem advisable, but any changes which materially increase the cost of manufacture shall be paid for at a fair price, to be determined by the contracting parties.

### 5. MARKING PARTS DURING MANUFACTURE.

All parts of carriages shall be marked by the inspector as early as practicable in their fabrication and thereafter these marks must always remain on the piece, being transferred from place to place in the presence of the inspector, as may be necessary. No part shall be assembled into a carriage unless it bears the inspector's marks.

### 6. METALS TO BE EMPLOYED.

The metals composing the different parts of the carriages will be indicated on the drawings, either general or detailed, and departure from these indications will be made only by authority of the officer approving the drawings.

Two kinds of steel for castings are distinguished: No. 1 is intended for use in castings of very mild steel in which the presence of blow holes may be permitted when, in the judgment of the inspector, they are not sufficiently large or numerous to materially affect the value of the casting for the purpose for which intended. No. 2 is to be used in pieces in which blow holes will not be allowed.

Cast steel of either grade must not contain more than six one-hundredths (0.06) of 1 per cent of phosphorus.

Three grades of worked steel are distinguished: No. 1 is very mild steel for rolled plates or shapes and for other parts when specially indicated. No. 2 is harder and is for general use for forgings; it will be employed for steel parts when not otherwise specified. No. 3 is still harder and is to be used for rollers, axles, elevating screws, and other parts when specially indicated.

All steel pieces shall be annealed after casting or forging and before being submitted for test; the temperature of annealing must be at least 1,500° F. (bright salmon) for castings, and at least 1,300° F. (bright cherry) for forgings.

Cast iron should be of the gray variety and two kinds are distinguished: No. 1 is ordinary cast iron and No. 2 is high quality cast iron or gun iron. Gun iron is called for only when specified.

Two kinds of bronze are used, which should be made of the following proportions:*

| | Copper. | Tin. | Zinc. |
|---|---|---|---|
| No. 1 | 88 | 10 | 2 |
| No. 2 | 96 | 4 | Trace. |

No. 1 is to be used for friction bearings and ordinary castings, and No. 2 for hydraulic cylinders and parts that should be malleable. All alloy castings must be made of new metals, and be sound, clean, and of uniform grain and texture.

All pieces used in the construction should be sound, of uniform quality and condition, and free from seams, cracks, or other defects. All hammering, etc., for the purpose of consolidating the metal or concealing defects is distinctly forbidden.

No piece shall be accepted as to physical qualities until it shall have satisfactorily passed the prescribed tests.

### 7. ALLOWANCE OF METAL FOR TESTS.

All matters relating to the character, number, and location of the tests necessary to assure satisfactory physical qualities in the material delivered shall, when not prescribed in the contract, be decided by the inspector, and manufacturers shall ascertain the instructions of the inspector before proceeding with the manufacture of the piece.

The manufacturers shall always allow, without cost to the United States, sufficient additional length or size to the pieces to furnish the test specimens required. Any metal required by the manufacturers for their own mechanical tests at the various stages of manufacture shall be provided for in additional length or size of the pieces over that required by the United States for the tests for acceptance, and, in no case, unless by special authorization of the inspector, shall the manufacturers use for their own tests any of the metal or length of piece required by the United States.

### 8. FORM, NUMBER, AND POSITION OF TEST SPECIMENS.

The forms and sizes of tensile test specimens will be as indicated in the following table, No. 1:

TABLE I.

| Form and metal. | Length of stem between gauge marks. | Diameter of stem. | Thickness of stem. | Width of stem. |
|---|---|---|---|---|
| Cylindrical: | *Inches.* | *Inches.* | | *Inch.* |
| Steel and wrought iron | 2 | 0.505 | | |
| Cast iron | Tenacity specimen. | 1.129 | | |
| Copper and bronze | 2 | 0.798 | | |
| Flat: | | | | |
| All metals except cast iron | 2 | | Same as piece | 1.0 |

All specimens will be provided with heads, as may be required. Cylindrical specimens will be used when the piece is sufficiently thick to finish the stem.

---

* Other mixtures may in special cases be authorized by the Chief of Ordnance.

In general each of the more important pieces should be tested in three places and pieces of less importance in one or two places, while minor pieces may be represented by heat tests or the test of a similar extra piece manufactured for the purpose.

The specimens from castings that have received no other treatment than annealing may generally be taken from coupons cast on the piece; those from other pieces should, when practicable, be taken within the finished lines of the pieces prolonged. Specimens should always be so taken that they will fairly represent the pieces the physical qualities of which they are intended to determine.

### 9. COST OF SPECIMENS.

Each test specimen required by the United States that shows in each particular qualities as high as those stated for the metal in Table No. IV, paragraph 11, and that is taken from a piece that is provisionally accepted, will be paid for by the United States at the following prices, viz:

| | |
|---|---|
| For preparation of each cylindrical test specimen | $2.00 |
| For preparation of each flat test specimen | .75 |
| For testing and recording test of each specimen | .50 |

All other expenses involved in the preparation and test of the test specimens will be borne by the manufacturers:

### 10. TEST OF SPECIMENS.

If the manufacturers possess a satisfactory testing machine, and the results obtained with such testing machine are found to be comparable with those obtained with the United States testing machine at Watertown Arsenal, then the specimens required by the United States shall be tested by the manufacturers in such manner as shall be prescribed by the Chief of Ordnance and in the presence of the inspector, and the inspector shall be furnished with the original notes of the several tests that they may be worked up in his office. The United States testing machine at Watertown Arsenal and tests made on it shall always be considered as standard, and any or all specimens may be tested at that place if desired by the United States.

If the manufacturers have no satisfactory testing machine, the Chief of Ordnance may provide for testing the required specimens on any machine satisfactory to the United States, and the cost shall be charged to the manufacturers.

All specimens which are to be tested outside the manufacturers' works, excepting those special additional specimens taken by the United States for information, shall be sent to the place of testing by the manufacturers, by express, at their own expense. All specimens shall pass through the inspector's hands for inspection and record.

Summaries of the results of tests of specimens not made at the manufacturers' works will be furnished to the manufacturers for their information, but shall be regarded as strictly confidential prior to their publication by the Government.

### 11. PHYSICAL QUALITIES.

The following table, No. II, shows the physical qualities that are desired for the various metals employed and which the manufacturers shall aim to obtain:

TABLE II.

| Metal. | Tensile strength. | Elongation after rupture. |
|---|---|---|
| | *Lbs. per sq. in.* | *Per cent.* |
| Cast steel, No. 1 | 65,000 | 20 |
| Cast steel, No. 2 | 75,000 | 16 |
| Forged steel, No. 1 | 65,000 | 30 |
| Forged steel, No. 2 | 75,000 | 25 |
| Forged steel, No. 3 | 95,000 | 18 |
| Wrought iron | 55,000 | 30 |
| Cast iron, No. 1 | 20,000 | .... |
| Cast iron, No. 2 | 30,000 | .... |
| Bronze, No. 1 | 45,000 | .... |
| Bronze, No. 2 | 38,000 | .... |
| Copper | 35,000 | 25 |

The following table, No. III, shows the required mean physical qualities of the various metals employed as exhibited by the prescribed test specimens:

TABLE III.

| Metal. | Tensile strength. | Elongation after rupture. |
|---|---|---|
| | *Lbs. per sq. in.* | *Per cent.* |
| Cast steel, No. 1 | 60,000 | 18 |
| Cast steel, No. 2 | 70,000 | 14 |
| Forged steel, No. 1 | 60,000 | 28 |
| Forged steel, No. 2 | 70,000 | 22 |
| Forged steel, No. 3 | 93,000 | 16 |
| Wrought iron | 50,000 | 25 |
| Cast iron, No. 1 | 17,000 | .... |
| Cast iron, No. 2 | *28,000 | .... |
| Bronze, No. 1 | 40,000 | .... |
| Bronze, No. 2 | 35,000 | .... |
| Copper | 32,000 | 22 |

* Cast iron No. 2 must not show a tensile strength of more than 37,000 pounds per square inch.

The following table, No. IV, shows the minimum allowable physical qualities of the various metals employed as exhibited by the prescribed test specimens:

TABLE IV.

| Metal. | Tensile strength. | Elongation after rupture. |
|---|---|---|
| | *Lbs. per sq. in.* | *Per cent.* |
| Cast steel, No. 1 | 55,000 | 15 |
| Cast steel, No. 2 | 65,000 | 10 |
| Forged steel, No. 1 | 55,000 | 25 |
| Forged steel, No. 2 | 65,000 | 20 |
| Forged steel, No. 3 | 90,000 | 15 |
| Wrought iron | 45,000 | 22 |
| Cast iron, No. 1 | 15,000 | .... |
| Cast iron, No. 2 | 25,000 | .... |
| Bronze, No. 1 | 38,000 | .... |
| Bronze, No. 2 | 32,000 | .... |
| Copper | 30,000 | 20 |

The test at each place shall consist primarily of the test of a single specimen. If this specimen shows in each particular physical qualities as high as those stated for the metal in Table III, the test shall be regarded as satisfactory. If this specimen does not fulfill this condition, but shows in each particular physical qualities as high as those stated for the metal in Table IV, an additional specimen may, at the request of the manufacturer, be taken from the vicinity of the first specimen, and if the mean of the results of the test of these two specimens show in each particular physical qualities as high as those stated for the metal in Table III, the test shall be regarded as satisfactory. If the first specimen shows physical qualities lower in any particular than those stated in Table IV, two additional specimens may, at the request of the manufacturers, be taken from the vicinity of the failing specimen, and if each of these two specimens shows in each particular physical qualities as high as those stated for the metal in Table III, the test shall be regarded as satisfactory.

No further test (unless there be intervening treatment) should in general be made; but the inspector may, in his discretion, at the request of the manufacturers, authorize a continuation of the test. In this case, however, the test shall not be regarded as satisfactory if more than one-third of the specimens fail to show in each particular physical qualities as high as those stated for the metal in Table IV, or if, one or more specimens so failing, each of the others does not show in each particular physical qualities as high as those stated in Table III.

### 12. RETESTING.

The inspector may, in his discretion, allow the manufacturers to treat the pieces failing to satisfactorily pass the preceding tests and present them for a new test, to be conducted in the same manner as the first test; but care should be taken to put the metal in the best condition before submitting it for test, as a second test will rarely be allowed.

### 13. BALLISTIC TESTS.

As many steel castings as the inspector may desire, generally one from each heat, shall, after the tensile test, be selected by the inspector and subjected to the following ballistic test: One projectile from a 3-pounder rapid-firing gun to be fired against the test casting, the point of impact to be not less than 3 inches from the edge of the casting. If the casting be thick and the projectile does not pass completely through it, a second shot is to be fired under similar conditions, the point of impact to be not less than 6 inches from the point of previous impact. Under this test the casting must not be cracked nor materially weakened for the purpose for which it is intended, the inspector to be the judge of the gravity of the injury produced. If any casting fails to satisfactorily pass this test, all castings from the same heat shall be considered as unsatisfactory, but each important casting may be subjected to the ballistic test and passed or rejected on the results of its own test alone.

### 14. WORKING TESTS.

In addition to the preceding tests, all metal that is to be bent, punched, hammered, or otherwise wrought during the manufacture shall be subjected to such working tests as the inspector may consider necessary to insure the ability of the metal to satisfactorily endure the operations to which it is to be subjected.

### 15. HYDRAULIC PRESSURE TEST.

Copper tubes will be subjected to an interior hydraulic pressure determined from the formula $P=12000\frac{T}{D}$, in which P represents the pressure in pounds per square inch, T the thickness, and D the interior diameter of the tube in inches.

## 16. ACCEPTANCE OF PIECES AND CONDEMNATION FOR DEVELOPED DEFECTS.

Pieces that satisfactorily meet all the requirements of these specifications will be accepted as to physical qualities by the United States and be considered delivered, but will be finally accepted only when the machine finishing has progressed so far as to preclude the possibility of condemnation for defects developed in machining. The inspector of material should promptly notify the manufacturers of the existence of any defect which in his opinion will make the final acceptance of a piece doubtful, and will immediately condemn any piece having defects which are of such gravity as to certainly prevent final acceptance.

Manufacturers shall promptly replace, without charge, any piece which may be condemned at any time after delivery for defect developed in machining, and shall ship the replacing piece, charges prepaid, to the place of condemnation. The condemned piece will, if the manufacturers desire, be shipped back to them at their expense.

## 17. PURCHASE OF MANUFACTURED MATERIAL BY THE CONTRACTORS.

No order shall be given for manufactured material outside of the United States without the authorization of the Chief of Ordnance.

The contractor may purchase manufactured material required for the construction of carriages, but the Chief of Ordnance shall have the right to refuse to accept material manufactured by a subcontractor from whom a direct bid for such material would in no case be entertained. The inspection of the manufacture of purchased parts shall, if the Chief of Ordnance desires, be at the works of the subcontractor, to whom all the provisions of these specifications not in their nature inapplicable to his case shall apply equally with the original contractor. When the inspection is at the works of a subcontractor the inspector at those works will correspond directly with the subcontractor, informing the inspector at the works of the contractor of the acceptance of material as to physical qualities and any peculiarities of the manufacture that it may be desirable that he should know, notifying him also of the shipment of material and the marks of identification thereon. He will forward reports of tests to the Chief of Ordnance through the inspector at the contractor's works, who will inform the contractor of the acceptance of material as to physical qualities and, when desired, will furnish him with summaries of the records of tests.

For bolts, nuts, rivets, and other articles manufactured in quantity for the trade, inspection will be confined to an examination to determine that the articles are free from defects and equal to the best commercial standard.

## 18. FINISHING AND ASSEMBLING.

All contact surfaces should be machine finished, and all finished surfaces should be protected from rust during manufacture.

Bolt and rivet holes which are punched must be reamed to finished size, the punched diameter not to exceed two-thirds of the finished. They should be finished in place where they pass through pieces which are to be in juxtaposition, in order that they may correspond exactly. Machine riveting is preferred.

All bolts should be turned, and made of easy or tight fit according to their use. The threaded portions of bolts should be of such length that there will remain one thread above and two below the nut when the latter is screwed home. When required, nuts will be locked to prevent unscrewing.

When finished, all carriages will be completely assembled and set up by the manufacturers in their establishment, loaded with a weight equal to that of the piece which they will have to support, and maneuvered; and all hydraulic and pneumatic cylinders, pipes and pipe connections pertaining to the carriages will be submitted to a pressure test of the fluid which they are to contain equal to twice the pressure to be used in service.

### 19. MARKING AND PAINTING.

The bolts and nuts of delivered carriages shall be marked in place after the maneuvering test to indicate clearly their places.

After delivery and before shipment all unfinished surfaces will be given, when practicable, at least one coat of paint.

### 20. DELIVERY AND PREPARATION FOR SHIPMENT.

Carriages made of accepted material, properly machine finished and assembled, and that maneuver properly in the manufacturers' establishment shall be considered delivered.

The manufacturers shall, without charge, properly prepare and securely pack such carriages for shipment; taking them apart if required and protecting machined surfaces from rust; the carriages or parts shall then be placed, without charge, on board cars, where they can be taken up by some convenient shipping line for transportation by the United States. One week will be allowed to prepare a carriage for shipment, and for time consumed in excess of this period the same penalty will be exacted as for nondelivery on time under the contract.

### 21. PROOF AND FINAL ACCEPTANCE.

The final acceptance of each carriage will be made only after it has satisfactorily undergone the firing of five proof rounds; but if any carriage be not proved within three months after it shall have been delivered it shall be considered finally accepted. Time occupied in packing and transportation not to be counted.

If the carriage be of the manufacturers' design they shall be responsible for all failure under proof, but if of a design furnished by the Ordnance Department they shall be responsible only for failure due to defective material or workmanship.

The proof will be conducted by the Ordnance Department, but the expense of the proof of those carriages failing on proof shall be borne by the manufacturers.

D. W. FLAGLER,
*Brigadier-General, Chief of Ordnance.*

ORDNANCE OFFICE, WAR DEPARTMENT,
*February 28, 1891.*

# APPENDIX 22.

## *INSTRUCTIONS TO BIDDERS AND SPECIFICATIONS GOVERNING THE MANUFACTURE OF SPRING RETURN CARRIAGES FOR 12-INCH B. L. RIFLED MORTARS.*

### PART I.—INSTRUCTIONS TO BIDDERS.

The mortar carriages for which proposals are invited under newspaper advertisement dated Ordnance Office, War Department, Washington, D. C., February 28, 1891, must conform in material and dimensions to the drawing and specifications to be had at this office. But bidders may also make proposals upon drawings of their own, embodying substantially the same design and principles.

Bidders will state a price for each carriage, the time within which the first carriage will be delivered, and an interval of time for the delivery of each carriage thereafter. It is desired that the first carriage be delivered as far in advance of the others and as early as possible. They will also state a price for the number, 25, of carriages, should that number be desired instead of 8.

The Chief of Ordnance shall have the right to order additional carriages in limited numbers at the same price and rate of delivery. The right is reserved to waive informalities and to reject any or all bids.

Envelopes containing the proposals should be marked "Proposals for mortar carriages," to guard against premature opening, and be addressed to the Chief of Ordnance, U. S. Army, Washington, D. C.

Copies of the advertisement, of these instructions to bidders, of the specifications, both special and general, and of the drawing must accompany and form part of the proposals, and the bidder's guaranty must be filled out as indicated thereon.

The bidder to whom award is made must execute a contract in quintuplicate, with good and sufficient sureties, for the faithful performance thereof within ten (10) days after receiving the blank forms.

The contract will stipulate that for each day of delay in the delivery of any carriage after the time stated in the proposal there will be deducted from the price to be paid therefor the sum of ten dollars ($10). This per diem deduction in price to be in lieu of the fifth section of the regular contract form unless, in the opinion of the Chief of Ordnance, continuous or great delay or other serious default shall occur, in which case, to protect its interests, the United States may apply the provisions of said fifth section and waive further per diem deduction in price.

Seventy-five (75) per cent of the price of each carriage will be paid upon its delivery and twenty-five (25) per cent upon its final acceptance.

## PART II.—SPECIFICATIONS.

1. These specifications are in addition to the general specifications for carriages and parts of carriages.

2. The manufacturer will furnish all parts of the carriage (except the Belleville springs and the holding-down bolts), the ring for attaching the elevating apparatus to the mortar, and the floor plates surrounding the carriage.

3. The carriage will conform to the general drawing forming part of these specifications, modifications in which must receive the approval of the Chief of Ordnance. The detailed drawings will be made by the manufacturer.

4. The carriage will consist of a base plate or lower roller path of gun iron, secured by 24 1¾-inch wrought iron bolts to the platform. This base plate will be cast in a single piece.

5. Upon the base plate rests a live roller ring of 24 forged steel conical rollers, protected from dust inside and outside by easily removable guard plates.

6. Upon the roller ring rests the upper roller path and supporting plate of the carriage, cast in one piece, of gun iron.

7. Upon the supporting plate will be bolted two side frames or flasks and a cross transom, all of gun iron. The side frames will be formed to receive the trunnion carriages, the recoil, and returning apparatus. Cylinders will be cast as part of them, inclined at angles of 50° to the horizon and bored to 9.6 inches interior diameter. These cylinders will be produced downwards by cylinders of gun iron bolted to their lower ends by means of flanges. Ratchets will be formed for a short distance upon the side frames near the points of rest of the lower ends of the trunnion carriages to give points of support for pinch bars for raising the latter to their places should the mortar at any time fail to return entirely to the firing position after recoil.

8. The trunnions will rest in bearings, bushed on the lower sides with bronze, formed in trunnion carriages of cast steel, No. 1. These carriages will embrace and slide upon guideways or slides inclined at an angle of 50° with the horizon, formed upon the inner sides of the cylinders in the side frames. The bearing surfaces, upper and lower, will be lined with bronze strips riveted on with brass rivets. Cast on to the upper ends of the trunnion carriages will be brackets projecting right and left into the spring cylinders and resting on the tops of courses of Belleville springs. In the upper end of the upper side of each trunnion carriage will be formed an oil cup or cavity with cover for oiling the upper faces of the slides. The cap squares to be of cast iron and provided with elastic material for softening the shock of counter recoil. They will have a play of 0.01 of an inch between their lateral supports. The bronze bushings will be keyed to the trunnion beds to prevent sliding around.

9. Into the lower ends of the trunnion carriages will be keyed piston rods 3½ inches in diameter, with the pistons formed on them, of forged steel, No. 3. The pistons will be covered with bronze or brass.

10. Bolted and keyed to the side frames and the extensions of the spring cylinders will be two hydraulic recoil cylinders 7.5 inches in interior diameter, of cast steel, No. 2, with return passages cast in them. The two hydraulic cylinders will be connected by pipes at their lower ends. They will be provided with emptying and filling plugs.

11. Gun iron lateral guides are bolted to the side frames and bear against the reinforce of the mortar to keep its axis in the same vertical plane.

12. The elevating gear is attached to plates bolted and keyed to the trunnion carriages, the keys being arranged for easy driving in and out. The spindles or shafts must be arranged to prevent sliding in the direction of their length.

13. The teeth of all gears and racks in the elevating and traversing gear must be machine finished.

14. The carriage will be surrounded by cast-iron floor plates and a training circle of gun iron graduated in half degrees from 0 to 360°. A pointer being attached to the carriage such that angles of 3′ may be read. The training circle shall be easily removable for reaching the exterior of the live roller ring.

15. The mortar will rest, through the medium of the trunnion carriages, on two courses of Belleville springs carried in cylinders in the side frames.

16. There must be supplied with each carriage one shot truck, with movable tray, as shown on the general drawing; one threaded rod, with nuts and washers, for putting in Belleville springs; one Bridge wrench for compressing the latter, and one pair of shot tongs.

D. W. FLAGLER,
*Brigadier-General, Chief of Ordnance.*

ORDNANCE OFFICE, WAR DEPARTMENT,
*February 28, 1891.*

# APPENDIX 23.

## *INSTRUCTIONS TO BIDDERS AND SPECIFICATIONS FOR THE MANUFACTURE OF TYPE AND SERVICE 8-INCH, 10-INCH, AND 12-INCH SINGLE-CHARGE, STEEL BREECH-LOADING GUNS, UNDER SECTION 2 OF THE ACT MAKING APPROPRIATIONS FOR FORTIFICATIONS, ETC., APPROVED AUGUST 18, 1890, AS MODIFIED BY THE ACT MAKING APPROPRIATIONS FOR FORTIFICATIONS, ETC., APPROVED FEBRUARY 24, 1891.*

### INSTRUCTIONS TO BIDDERS.

The manufacture of type and service 8-inch, 10-inch, and 12-inch breech-loading steel guns, for which proposals are invited under newspaper advertisement of this date, must be in accordance with the specifications furnished by this office.

Bidders will state a price for the type gun of each caliber and ammunition for its test, and the date within which each will be presented for test, as required by the specifications; also a price per gun of each caliber for the service guns, and ammunition for the proof and the time within which each gun of each caliber will be delivered, as required by the specifications, after receiving written notification that the type gun is satisfactory to the Government.

Bids will be received for six (6) 8-inch, thirteen (13) 10-inch, and six (6) 12-inch guns, to be constructed on the Pacific coast.

Copies of the advertisement, of these instructions to bidders, and specifications, *accompanied by such drawings as will show the construction of the guns in detail, to be furnished by the person or manufacturer submitting the proposal,* must be attached to and form part of proposals, and the bidder's guarantee must be filled out as indicated thereon.

The right is reserved to waive informalities and to reject any or all bids.

Envelopes containing proposals should be marked, "Proposals for 8-inch, 10-inch, and 12-inch Breech-Loading Steel Guns," and be addressed to "The Chief of Ordnance, U. S. Army, Washington, D. C."

The bidder or bidders to whom award is made must execute a contract, in quintuplicate, with good and sufficient sureties for the faithful performance thereof, within twenty (20) days after receiving the forms.

Contract or contracts for these guns will stipulate, in addition to the stipulations of the regular contract form (copy of the form may be had on application), that if the service guns are not delivered by the proposed times there shall be deducted ten (10) dollars per day from the price of each gun for each day of delay in delivery. This per diem deduction in price to be in lieu of the provisions of the 5th section of the regular contract form, unless continuous and great delay or other serious default shall occur, in which case to protect its interests the United States may apply the provisions of the 5th section and waive further per diem deduction in price.

**The attention of bidders is invited to the provisions of the laws authorizing the purchase of these guns, as follows:**

An act making appropriations for fortifications and other works of defense, for the armament thereof, for the procurement of heavy ordnance for trial and service, and for other purposes.—Approved, August 18, 1890.

[Extract.]

SEC. 2. That the Secretary of War is hereby authorized and directed to purchase under contract, after due advertisement inviting proposals, and at prices which the Board of Ordnance and Fortification shall adjudge to be fair to the manufacturer and for the interest of the United States, twenty-five eight-inch, fifty ten-inch, and twenty-five twelve-inch guns, all of which guns shall be breech-loading, single-charge steel guns, and of weight and dimensions to be prescribed by the Board, and shall fulfill the conditions hereinafter provided: *Provided*, That if two or more persons, citizens of the United States, submit proposals to furnish said guns, either in part or in whole, at prices not materially different from each other, contracts may be awarded, in such proportion, among the citizens submitting such proposals as the Secretary of War may direct. One type gun of each of the above-mentioned caliber, with the proper supply of ammunition therefor, shall be presented for test at such place and within such time as the contract shall provide, and shall be subjected to such tests in respect to accuracy, range, power, endurance, and general efficiency as the Board of Ordnance and Fortification shall have prescribed. All the other guns of each caliber, with the proper supply of ammunition, shall be delivered at such place and within such times as the contract shall provide, and shall be subjected to the ordinary service test of ten rounds with the full charge and weight of projectile, which shall develop the standard power prescribed for the gun. If the type gun sustains the prescribed test to the satisfaction of the Board of Ordnance and Fortification, it and each of the other guns which sustains the ordinary service test, and the ammunition expended in such test, shall be accepted under the contract. All guns manufactured under these contracts, including the type guns, shall be subjected to inspection at all stages of manufacture, and no change whatever shall be made in the material, mode of manufacture, or dimensions of the guns for service from those employed in the type gun without the approval of the Secretary of War. Payment for each gun and ammunition for testing same, including cost of transportation, shall be made upon the satisfactory completion of the prescribed test for that gun. All tests of guns shall be made in the presence of the Board and of the person presenting the gun, or his authorized agent, and due regard shall be paid to suggestions offered by him with respect to the mode of making such test.

That under the provisions of this section there shall not be expended or contract or contracts entered into involving the Government in an aggregate expenditure exceeding three million seven hundred and seventy-five thousand dollars, nor an expenditure on the part of the Government in any one fiscal year in excess of one million dollars. And all guns and materials purchased under the authority of this section shall be of American manufacture and furnished by citizens of the United States: *Provided further*, That contracts may be made for not exceeding one-fourth of the guns herein provided for, to be constructed on the Pacific coast, in the discretion of the Secretary of War: *Provided further*, That all expenditures made under this section shall be paid from the amount made available and provided for in section six of the "Act making appropriations for fortifications and other works of defense, for the armament thereof, for the procurement of heavy ordnance for trial and service, and for other purposes," approved September twenty-second, eighteen hundred eighty-eight, and the Secretary of War shall embrace in his estimates of appropriations for fortifications from time to time the amounts necessary to carry out all contracts made hereunder.

An act making appropriations for fortifications and other works of defense, for the armament thereof, for the procurement of heavy ordnance for trial and service, and for other purposes.—Approved February 24, 1891.

[Extract.]

That section two of "An act making appropriations for fortifications and other works of defense, for the armament thereof, for the procurement of heavy ordnance for trial and service, and for other purposes," approved August eighteenth, eighteen hundred and ninety, is hereby modified and enlarged so that the amount authorized to be expended thereunder be increased to four million two hundred and fifty thousand dollars, to be expended on the terms and conditions and for the purposes therein set forth, except that fifty thousand of said sum shall be reserved to cover all expenses other than the powder and projectiles incident to the tests and inspection of the guns, and also that the Secretary of War be authorized to contract thereunder for such less number of guns than one hundred as he may deem for the best interests of the Government.

## SPECIFICATIONS.

### PART I—TYPE GUNS.

### *1. Weight and dimensions.*

The weight and dimensions shall be as given in the following table. The principal dimensions only are specified, that the manufacturers may be free to adopt such details as they deem best. The guns must have the usual trunnions, and though the diameter and the distance between rimbases specified in the table need not be strictly adhered to, they are desirable, in order that special carriages may not be required for testing or mounting the guns:

| Caliber of gun. | Length of bore from face of obturator to face of muzzle. | | Diameter of Trunnions. | Distance between rimbases. | Weight. | Allowed variation in weight. |
|---|---|---|---|---|---|---|
| *Inches.* | *Calibers.* | *Inches.* | *Inches.* | *Inches.* | *Long tons.* | *Long tons.* |
| 8 | 32 | 256.0 | 10.0 | 32.5 | 14.25 | ±¼ |
| 10 | 34 | 340.0 | 12.0 | 42.0 | 30.00 | ±½ |
| 12 | 34 | 408.0 | 14.5 | 49.8 | 52.00 | ±¾ |

### *2. Inspection of the manufacture.*

The manufacture, including both the manufacture of the material and the construction or finishing and assembling, shall be open to inspection in all its details by the officers and employés of the Ordnance Department assigned to duty for that purpose, to the end that, if the type guns sustain the prescribed tests, similar methods and equally good and uniform results may be secured in the manufacture of the service guns.

Full and detailed reports of all the operations of manufacture shall be made by the inspector, and they will be the basis on which to apply the limitations and variations prescribed for the service guns. A copy of these reports will be furnished the manufacturers.

The manufacturers shall give every facility for performing this duty and render all necessary assistance; they shall inform the inspector of the chemical composition of each and every ingot, part of ingot, or casting which they propose to use, together with a statement of its casting, size, and condition; they shall inform him, or such of his assistants as he may designate, of the time at which each operation connected, either directly or indirectly, with the manufacture is to take place, and shall give him such notification as may be required to insure his witnessing or verifying any particular part of an operation which he may specify: they shall furnish him with a copy of all the plans and working drawings of the guns, of all directions, orders, or instructions for material or machine work connected with the manufacture of the guns, and of the results of all chemical analyses and mechanical tests in any way connected with the guns to be furnished; they shall provide all necessary labor, and allow the use of the necessary instruments for making fine measurements, tools, and implements required by the inspector and his assistants in the performance of their duties, and they shall provide within their works suitable and satisfactory office room for records, drawings, books, etc., which may be used exclusively by the inspector and his assistants.

The officers and employés referred to shall have free access at all times to all parts of the manufacturers' works. The details of the operations carried on at the works will be considered confidential so far as the manufacturers may desire.

### 3. *Material.*

The guns must be made of steel. The method of producing the metal, the methods of forging and treatment if forged and treated, and the qualities of the metal in the guns may be such as the manufacturers shall determine upon. The number, size, and positions of the tangential tensile test specimens to be taken from the various parts entering into the construction of the guns to determine the qualities of the material shall be as follows:

*From tubes, jackets, and trunnion hoops.*

| Caliber of gun. | Designation of piece. | Number of specimens from— | | Size of specimens. | | Minimum distance of axis from end of piece. |
|---|---|---|---|---|---|---|
| | | Breech end. | Muzzle end. | Length of stem. | Diameter of stem. | |
| *Inches.* | | | | *Inches.* | *Inches.* | *Inches.* |
| 8 and 10 | Tube | 3 | 3 | 3.0 | 0.564 | 1.50 |
| | Jacket | 4 | 4 | 3.0 | 0.564 | 1.50 |
| 12 | Tube | 4 | 4 | 3.0 | 0.564 | 1.50 |
| | Jacket | 4 | 4 | 3.0 | 0.564 | 1.50 |
| 8, 10, and 12 | Trunnion hoop | 4 | 4 | 4.0 | 0.564 | 1.25 |

*From cylindrical hoops.*

| Rough-finished size of hoops. | Number of test specimens. | | | Size of specimens. | | Minimum distance of axis from end of hoop. |
|---|---|---|---|---|---|---|
| | From breech end. | From muzzle end. | From hoop. | Length of stem. | Diameter of stem. | |
| | | | | *Inches.* | *Inches.* | *Inches.* |
| Not more than 8" inside diameter. Not more than 30" long | | | 1 | 2.0 | 0.505 | 1.15 |
| Not more than 8" inside diameter. More than 30" long | 1 | 1 | | 2.0 | 0.505 | 1.15 |
| More than 8" inside diameter. Not more than 16" inside diameter. Not more than 30" long | | | 2 | 3.0 | 0.564 | 1.25 |
| More than 8" inside diameter. Not more than 16" inside diameter. More than 30" long | 2 | 2 | | 3.0 | 0.564 | 1.25 |
| More than 16" inside diameter. Not more than 34" inside diameter. Not more than 26" long | | | 3 | 4.0 | 0.564 | 1.25 |
| More than 16" inside diameter. Not more than 34" inside diameter. More than 26" long | 3 | 3 | | 4.0 | 0.564 | 1.25 |
| More than 34" inside diameter. Not more than 25" long | | | 4 | 4.0 | 0.564 | 1.25 |
| More than 34" inside diameter. More than 25" long | 4 | 4 | | 4.0 | 0.564 | 1.25 |

But for cylindrical hoops the manufacturers may make the testing representative, when two or more hoops are made from the same ingot in the same manner and are treated together, if treated—provided, that at least one-half of the total number of hoops made from any one ingot shall be tested, and the inspector shall be satisfied that the nontested hoops are fairly represented by the one tested.

*From wire.*—One specimen from each coil or single length as manufactured.

*From parts of breech mechanism.*

| Name of part. | Caliber of gun—8-inch, 10-inch, and 12-inch. | Size of specimen. | | Minimum distance of axis from end of piece. |
|---|---|---|---|---|
| | | Length of stem. | Diameter of stem. | |
| | | *Inches.* | *Inches.* | *Inches.* |
| Breechblock | Two from every second | 3.0 | 0.564 | 1.25 |
| Spindle | Two from head of every second. | 3.0 | 0.564 | 1.25 |
| Gas-check cups and gas-check rings. | Two from one additional forging for test. To be made for each 4. | 3.0 | 0.564 | 0.75 |
| Hinge-pins, rollers, and bars for securing pins. | One from every third. | 3.0 | 0.564 | ........... |

But the nontested parts must be made from the same ingot, and, if treated, be treated with the parts by the tests of which they are to be represented, and the inspector must be satisfied that the nontested parts are fairly represented by the tests made. If these conditions do not exist each part shall be separately tested.

*From all the parts.*—Any other part by whatever name it may be designated shall be tested as is prescribed for the part to which it is most nearly assimilated in size and function in the gun, and if there be no similar part named in these specifications then the number and size of the tensile test specimens to be taken from it to determine these qualities shall be determined from a consideration of its length and diameter by the following general rule: The number of *places* at which a piece shall be tested shall be one if the piece is less than 50 inches long and shall be two if the piece is more than 50 inches long; the *number of specimens to be taken at each place* shall be two for an inside diameter varying from 8 to 11 inches, three for an inside diameter varying from 11 to 25 inches, and four for an inside diameter above 25 inches, and if the piece is less than 8 inches in inside diameter or is solid, one specimen shall be taken from each place; the specimens shall have a stem 3 inches long and 0.564 of an inch diameter, if possible, and otherwise a stem 2 inches long, and 0.505 of an inch diameter.

*From gun bodies.*—If the gun or the body of the gun is made in one piece, disks will be cut from both breech and muzzle, from each of which disks there will be detached interior and exterior initial tension rings in the usual manner prescribed by the Ordnance Department. There shall also be taken from the disk cut from the breech end twelve tangential tensile test specimens with stem 4 inches long and 0.564 of an inch in diameter; from the disk cut from the muzzle end six such tangential tensile test specimens, and from each disk two tangential compression test specimens 5 inches long and 1.129 inches in diameter: and two tensile test specimens shall be taken from each trunnion if the trunnions are made a part of the gun.

All these specimens shall be cut from the several parts and finished under the supervision of the inspector, and shall be marked by him. They shall be tested on a testing machine satisfactory to the United States, and in the presence of the inspector, to determine the apparent modulus of elasticity, elastic limit, elastic elongation, tensile strength, elongation after rupture, contraction of area, position of rupture, and character of fracture, by applying successive loads, beginning with 5,000 pounds per square inch and increasing by increments not greater than 10,000 pounds per square inch, with a sufficient number of loads increasing by increments of 1,000 pounds per square inch in the vicinity of the elastic limit to accurately determine that point. The original notes of these tests must be furnished the inspector.

Each part which the manufacturers decide to put into a gun shall be marked by the inspector. These marks must always be on the part, and before they are effaced in one place shall be transferred to some other place by the inspector. No part shall be assembled into a gun unless it bear the inspector's marks.

### 4. *Mode of manufacture.*

The mode of manufacturing the type guns may be such as the manufacturers may determine upon, but complete records of all the operations will be made. If the guns are built up, careful measurements of each of the parts will be made before it is put in place in the gun. These measurements to be within 0.001 of an inch when practicable or necessary to insure reproduction in the other guns; and all temperatures, shrinkages, tensions of wire-winding, compressions of the bore, and methods will be carefully noted.

### 5. *Supply of ammunition.*

The supply of ammunition to be furnished with each type gun shall be 350 rounds for 8-inch gun, 300 rounds for 10-inch gun, and 250 rounds for 12-inch gun.

The standard weights of projectiles shall be 300 pounds for 8-inch gun, 575 pounds for 10-inch gun, and 1,000 pounds for 12-inch gun. A variation not to exceed 1 per cent, more or less, from these weights will be allowed. These projectiles may be of cast iron.

The powder, if not of some well-known service type, must be satisfactory to the Department, stable and entirely trustworthy; the composition and process of manufacture must in any event be made known to the Department. The quantity of powder must be sufficient to fire the number of rounds prescribed.

### 6. *Place of delivery.*

The guns with the supply of ammunition must be delivered at the United States Proving Ground, Sandy Hook, N. J., or such other place as the Department may direct; but if delivery is directed at any other place than Sandy Hook the excess in cost of transportation thereto over the cost of transportation to Sandy Hook will be a separate charge against the United States.

### 7. *Power.*

The power shall be such as may be expressed by a muzzle energy of not less than 7,700 foot-tons (long) for 8-inch gun, 15,000 foot-tons (long) for 10-inch gun, and 26,000 foot-tons (long) for 12-inch gun.

### 8. *Range.*

The range shall for 20° elevation be about 11,000 yards for 8-inch gun, 13,650 yards for 10-inch gun, and 14,700 yards for 12-inch gun, and corresponding ranges shall be obtained with lower elevations.

### 9. *Accuracy.*

The standard of accuracy for all calibers shall be as given in the following table, and shall be approximately attained:

*Table of accuracy—25 per cent rectangles.*

| Range. | Vertical rectangle. | | Horizontal rectangle. | |
|---|---|---|---|---|
| | Height. | Width. | Length. | Width. |
| *Yards.* | *Feet.* | *Feet.* | *Yards.* | *Yards.* |
| 1,500 | 1.4 | 1.0 | | |
| 3,000 | 3.4 | 2.9 | | |
| 6,000 | | | 29.7 | 4.2 |
| 8,000 | | | 38.9 | 6.7 |
| 10,000 | | | 48.5 | 9.2 |

### 10. *Endurance.*

The endurance shall not be less than 350 rounds for 8-inch gun, 300 rounds for 10-inch gun, and 250 rounds for 12-inch gun, all with full charges; but after 300, 250, and 200 rounds or more may have been fired from the 8-inch, 10-inch, and 12-inch guns, respectively, the gun may be lined wholly or in part, when at least 50 rounds more will be fired. After this the general soundness and efficiency of the gun should not be materially impaired, except that a reasonable amount of erosion will be admitted. Should any material modification of the construction be made during the trial, at least 50 rounds with full charges shall be fired thereafter.

### 11. *General efficiency.*

As a proof of general efficiency the breech-mechanism should work freely and be convenient for operating, the opening and closing of the breech to be performed by hand without great difficulty by one man. The projectiles shall admit of being readily handled, inserted, and centered in the bore, and not be subject to injury or deformation either in handling or transportation.

### 12. *Rapidity of fire.*

A rapidity of fire of 20 rounds per hour for 8-inch gun, 15 rounds per hour for 10-inch gun, and 10 rounds per hour for 12-inch gun shall be attainable, using such appliances for loading as are employed by the Ordnance Department.

### 13. *Repairs.*

The repairs allowable during the entire test of a gun, exclusive of the insertion of a lining tube, will be confined to repairing or renewing parts injured during the tests. No alterations that may affect the general construction of any part will be made without the sanction of the Board of Ordnance and Fortification.

### *14. General conditions of test.*

The tests of these type guns shall be made in the presence of the Board of Ordnance and Fortification and of the agent or representative of the manufacturers. Due notice of the time and place of the test shall be given. Each of the guns may be subjected to preliminary firing, at the option of the manufacturers, before the prescribed test begins.

The time during the test when the special determinations of range, accuracy, and rapidity of fire shall be made shall be arranged in consultation between the Board of Ordnance and Fortification and the agent or representative of the manufacturers, and all the other conditions of the test not herein prescribed shall be determined by that Board, due regard being paid to suggestions offered by the manufacturers' agent or representative.

If the first type gun presented for test shall fail to satisfactorily fill the prescribed tests, the Secretary of War may, in his discretion, if the facts warrant such action, permit the manufacturers to present a second type gun of the same caliber.

### *15. Payments.*

Payment for each of the type guns, and the ammunition supplied for its test, shall be made on the satisfactory completion of the prescribed test for each gun on duly approved certificates of inspection and receipt.

## PART II—SERVICE GUNS.

The following specifications for service guns will be construed in connection with the provision of law that no change whatever shall be made in the material, mode of manufacture, or dimensions of the guns for service from those employed in the type gun without the approval of the Secretary of War.

### *1. Inspection of the manufacture.*

The manufacture, including both the manufacture of the material and the construction or finishing and assembling, shall be open to inspection in all its details by the officers and employés of the Ordnance Department assigned to duty for that purpose, and shall be satisfactory to the inspector, or such one of his assistants as he may designate, at all its stages.

The manufacturers shall give every facility for performing this duty and render all necessary assistance; they shall inform the inspector of the chemical composition of each and every ingot, part of ingot, or casting, which they propose to use, together with a statement of its casting, size, and condition; they shall inform him, or such of his assistants as he may designate, of the time at which each operation connected, either directly or indirectly, with the manufacture is to take place, and shall give him such notification as may be required to insure his witnessing or verifying any particular part of an operation which he may specify; they shall furnish him with a copy of all the plans and working drawings of the guns, of all directions, orders, or instructions for material or machine work connected with the manufacture of the guns, and of the results of all chemical analyses and mechanical tests in any way connected with the guns to be furnished; they shall provide all necessary labor and allow the use of the necessary instruments for making fine measurements, tools and implements required by the inspector and his assistants in the performance of their duties, and they shall provide within their works suitable and satisfactory office room for records, drawings, books, etc., which may be used exclusively by the inspector and his assistants.

The officers and employés referred to shall have free access at all times to all parts of the manufacturers' works. The details of the operations carried on at the works will be considered confidential so far as the manufacturers may desire.

The manufacturers must satisfy the inspector that the manufacture of the material and the construction or finishing and assembling of the guns are in accordance with the specifications, and the inspector may suspend the work on any part or any gun at any time if, in his opinion, the work is not in accordance with the specifications, informing the manufacturers and the Department of his reasons therefor, in writing, within twenty-four hours thereafter.

### *2. Material.*

The material in the service guns of each caliber shall be of the same kind, be made in the same manner, and have equally as good qualities as the material in the type gun of the same caliber; to determine these points the reports of the inspector of the material in the type guns shall be taken as the guide by the inspector of the material for the service guns as to kind of material and method of manufacture. The number, position, and size of the tangential tensile test specimens to be taken from the various parts entering into the construction of the service guns shall be as prescribed in paragraph 3, part 1, of these specifications, and they will be cut from the several parts and be marked and tested in the manner prescribed in that paragraph.

The physical qualities of each part of the service guns shall be at least equal to the physical qualities of the similar part in the type gun of the same caliber in elastic limit, tensile strength, elongation after rupture, and contraction of area, the mean of the determinations to be compared with the mean of the determinations for the part of the type gun, and no specimen to show qualities lower in any particular than the lowest record of the part for the type gun in that particular, unless the contracting parties may agree upon general tables of physical qualities, which shall be determined from all the results of test of the material of the type guns, and shall show average or mean qualities and qualities below which no specimen shall fall in any one particular, such tables to group together as many as possible of the various parts of the guns of the several calibers or of all the calibers.

No part of any gun shall be machine finished or assembled into the gun until it has been accepted as to physical qualities by the inspector.

### *3. Mode of manufacture.*

The mode of manufacturing the service guns shall be similar to that employed in the manufacture of the type guns, or such as will insure equal accuracy and certainty; to determine these points the report of the inspector of the manufacture of the type guns shall be taken as a guide by the inspector of the manufacture of the service guns. If the guns are built up the variations from the shrinkages absolutely obtained in the type guns shall not be greater than 0.003 of an inch on diameters, but if in the manufacture of the type guns it has been aimed to obtain certain definite shrinkages then the variations from these shrinkages in the service guns shall not be greater than the variations from prescribed shrinkages ordinarily allowed by the Ordnance Department in gun construction, except that for any particular zone or section where the variation from shrinkage aimed at in the type gun has been greater than is ordinarily allowed by the Ordnance Department the variation in the service guns may be as great as was absolutely obtained in the type gun at that zone or section. Temperatures used in assembling the service guns shall not be materially greater than were obtained in assembling the type guns.

If wire winding is used the tensions used in winding the service guns shall be the same as were obtained in winding the type guns.

If the guns or the bodies of the guns are made in one piece initial tension rings and test specimens shall be furnished as is prescribed for the type guns; the initial tensions determined shall not vary more than 10 per centum from the initial tensions which were found to exist in the type gun of the same caliber, and the mean physical qualities at breech and muzzle shall be at least equal in every particular to those shown by the type gun of the same caliber, no specimen being lower in any particular than the lowest record of the type gun in that particular.

The variations from prescribed diameters of chamber, bore within lands and to bottom of grooves, and in width of lands or grooves shall not be greater in the service guns than were actually obtained in the type guns. Suitable gauges, to be supplied by the manufacturers, shall be used for the rifling, the length of powder chamber, the threads in breech recess and on breechblock, and the several parts of the breech mechanism, to the end that uniformity may be obtained in manufacture and the parts of the breech mechanism be interchangeable.

Each part of a gun which is accepted as to physical qualities shall be marked by the inspector; these marks shall always be on the part, and before they are effaced in one place by any finishing operation shall be transferred to some other place by the inspector. No part shall be assembled into a gun unless it bears these marks.

The traces of two planes, one containing the axis of the bore and trunnions, and the other perpendicular thereto and containing the axis of the bore, will be marked on each gun at such points as may be required, and seats for the sights will be made and fitted as may be prescribed by the Ordnance Department; the weight and preponderance shall be determined and the muzzle stamped in accordance with a design furnished by the Department. The guns will bear no other marks or characters.

The outside of the guns shall be painted as required by the Ordnance Department for service guns.

### 4. *Supply of ammunition.*

The supply of ammunition to be furnished with each gun for proof shall be ten rounds; the projectiles to be of standard weight and of dimensions similar to those furnished with the type guns. The powder shall be similar to that furnished with the type guns, and a sufficient quantity shall be furnished to fire the number of proof rounds prescribed with full charges.

### 5. *Place of delivery.*

The guns, with the supply of ammunition, must be delivered at the U. S. Proving Ground, Sandy Hook, N. J., or at such other place as the Department may direct; but if delivery is directed at any other place than Sandy Hook, the excess in cost of transportation thereto over the cost of transportation to Sandy Hook will be a separate charge against the United States.

For shipment the parts of the breech mechanism must be detached from the piece and be separately and securely packed, being marked with the number of their respective piece. The bore must be well oiled and protected for shipment in the usual way required by the Ordnance Department for service guns.

### 6. *Conditions of service proof.*

Each of the guns may be subjected to preliminary firing, at the option of the manufacturers, before the proof is made; the cost of such preliminary firing will be paid for by the manufacturers.

Each of the ten proof rounds shall be fired with the full charge and weight of projectile, and shall develop the standard power prescribed for the gun in paragraph 7, part I, of these specifications, without showing any damage or defect.

### 7. *Payments.*

Payment for each gun and the ammunition supplied for the service proof shall be made on the satisfactory completion of that proof on duly approved certificates of inspection and receipt.

By authority of the Secretary of War:

D. W. FLAGLER,
*Brig. Gen., Chief of Ordnance, U. S. Army.*

ORDNANCE OFFICE, WAR DEPARTMENT,
*Washington, D. C., May 8, 1891.*

# APPENDIX 24.

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## *INSTRUCTIONS TO BIDDERS AND SPECIFICATIONS GOVERNING THE MANUFACTURE OF 8-INCH AND 10-INCH DISAPPEARING GUN CARRIAGES OF COL. BUFFINGTON'S MODIFIED DESIGN.*

### PART I.—INSTRUCTIONS TO BIDDERS.

The gun carriages for which proposals are invited under newspaper advertisement dated Ordnance Office, War Department, Washington, D. C., May 22, 1891, must conform in material and dimensions to the drawing and specifications to be had at this office.

Bidders will state a price for each carriage, and the time within which it will be delivered, the 8-inch carriage to take precedence.

The right is reserved to waive informalities and to reject any or all bids.

Envelopes containing the proposals should be marked "Proposals for disappearing carriages," to guard against premature opening, and be addressed to the Chief of Ordnance, U. S. Army, Washington, D. C.

Copies of the advertisement, of these instructions to bidders, of the specifications, both special and general, and of the drawing must accompany and form part of the proposals, and the bidder's guarantee must be filled out as indicated thereon.

The bidder to whom award is made must execute a contract in quintuplicate, with good and sufficient sureties for the faithful performance thereof within ten (10) days after receiving the blank forms.

The contract will stipulate that for each day of delay in the delivery of any carriage after the time stated in the proposal there will be deducted from the price to be paid therefor the sum of ten dollars ($10). This per piem deduction in price to be in lieu of the 5th section of the regular contract form, unless, in the opinion of the Chief of Ordnance, continuous or great delay or other serious default shall occur, in which case, to protect its interests, the United States may apply the provisions of said 5th section and waive further per diem deduction in price.

Seventy-five (75) per cent of the price of each carriage will be paid, in three equal installments, the last to be paid upon its delivery, and twenty-five (25) per cent upon its final acceptance.

### PART II.—SPECIFICATIONS.

1. These specifications are in addition to the general specifications for the manufacture and inspection of carriages and parts of carriages.

2. The manufacturer will furnish all parts of the carriages, the counterpoises and the rings for attaching the elevating apparatus to the guns. The Department will furnish the holding-down bolts, washers, and nuts.

3. The carriage will conform to the general drawings forming part of these specifications, modifications in which must receive the approval of the Chief of Ordnance. The detailed drawings will be made by the manufacturer.

4. The principal parts of each carriage are the rotating arms, the top carriage, the cheek plates or chassis, the elevating gear, the upper front roller path, the live rollers, the lower front roller path, the brackets for the rear traverse wheels, the rear traverse wheels, the rear traverse circles, the traversing gear, the loading crane.

5. The gun rests by its trunnions on the upper ends of the rotating arms in bearings bushed with bronze. The rotating arms are made of cast steel No. 1. They are pivoted near their middle points upon an axle of forged steel No. 3. The rotating arms of the 10-inch carriage are shown in the drawing to be built-up of forged shapes. Whether they shall be so made or shall be steel castings will depend upon the experience had in casting the arms for the 8-inch carriage.

6. The axle rests in bearings bushed with bronze, in the top carriage, which is formed with the two hydraulic cylinders in one piece of cast steel No. 2. In each cylinder are two throttling bars of forged steel No. 2, which pass through notches in the pistons. They serve to regulate the size of the orifices for the flow of the liquid past the pistons, being of variable cross-section. Their form will be indicated by the Department. The hydraulic cylinders are connected by a pipe at their front ends to equalize the pressure in them during recoil.

7. The piston rods, with the pistons formed on them, are made of forged steel No. 3, and are fastened by means of nuts to projections on the chassis. They are pierced throughout their length with holes one inch in diameter to permit the passage into the cylinders of liquid which comes to their forward ends through copper pipes, from a reservoir placed on the chassis. These pipes at their point of junction are provided with a check valve, which prevents the return of the liquid from the cylinder, and with a by-pass valve, which when opened permits the return flow of the liquid past the check valve. The object of this arrangement is to retain the gun in the position of recoil and to control its return to the firing position.

8. The top carriage runs upon rollers of forged steel No. 3, which are placed in recesses in the cheek plates. The axles of the rollers are of forged steel No. 2, and the rollers are bushed with bronze where the axles pass through them.

9. The cheek plates are made of cast steel No. 1, and are united by a transom, also of cast steel No. 1, and by the brackets for the rear traverse wheels. They are bolted at their forward ends to the upper front roller path. They have formed in them or bolted to them guides for the elevating racks.

10. The elevating rods are of forged steel No. 3. The journal bearings at their upper and lower ends are bushed with bronze. The lower ends of the rods are attached to elevating racks of forged steel No. 2.

11. The elevating hand wheels are of bronze. They are mounted on a through shaft, upon which are pinions of bronze gearing into spur wheels of cast steel, on the shaft with which are pinions of bronze gearing into the elevating racks.

12. The upper and lower front roller paths are of cast steel No. 1. Their inner parts form the pivot or pintle, which should be made with a play of ″.03 and have a spiral groove cut in one of the surfaces to facilitate lubrication. The lower one is fastened to the platform with eighteen 1¾-inch holding down bolts for the 8-inch, and eighteen 2-inch bolts for the 10-inch carriage.

13. The conical rollers are to be of forged steel No. 3.

14. The counterweight is of cast iron and weighs 16 tons for the 8-inch and 28 tons for the 10-inch carriage. It is suspended by two rods from a shaft joining the lower ends of the rotating arms. The rods are of forged steel No. 2 and at the lower ends sustain a platform of cast steel No. 1, upon which rests the counterweight.

15. The shaft from which the counterweight hangs is of forged steel No. 3. It passes through the lower ends of the rotating arms and into two sliding pieces forming a cross head, the holes in the rotating arms being bushed with bronze. It is keyed to the counterweight suspension rods and to the pieces with which it forms the cross head.

16. The cross-head pieces are of cast steel No. 1 and are lined on their principal bearing surfaces with bronze strips. The cross-head guides are formed on the inner sides of the cheek plates.

17. On the front of each cheek plate are projections such that a handspike may engage over them and in notches in the cross-head pieces for raising the counterweight and lowering the piece to the loading position should it not quite reach that position in recoil. A vertical ratchet is formed on one face of one of the cross head-pieces to be caught by a pawl on the cheek plate and hold up the counterpoise. This is in addition to the liquid arrangement for the same purpose.

18. The rear traverse wheels and their brackets are of cast steel No. 1. The axles of the wheels rest in ball bearings.

19. The worm shaft of the traversing gear is of forged steel No. 2, the worm being formed on it. The worm wheel is of bronze; the notched wheel over which the chain passes of cast steel No. 1; its shaft of forged steel No. 2; the bracket supporting the shaft of cast steel No. 1; and the pulleys for changing direction of the chain of forged steel No. 2. The teeth of all gears and racks in the elevating and traversing gear are to be machine finished.

20. The traversing chain lies around the rear traverse circle and is fastened to the parapet. It is provided with an arrangement for taking up the slack.

21. The rear traverse circle is of cast steel No. 1. It is cast in segments and fastened to the platform by 1½-inch holding-down bolts.

22. The loading crane is of wrought iron.

23. All bolts and rivets are of wrought iron.

24. All steel castings must be annealed, and care should be taken to insure uniform cooling both in casting and annealing.

25. The action of the carriage is as follows: Upon firing the piece the central pivot of the rotating beam moves in a horizontal line to the rear, carrying the top carriage with it; the lower end moves vertically upward, being constrained by the cross-head guides; the gun moves downward and to the rear in the arc of an ellipse. The energy of recoil is absorbed partly by raising the counterweight and partly by the resistance of the hydraulic cylinders. After loading the by-pass valve is opened and the surplus liquid allowed to flow from the hydraulic cylinders, permitting the piston rods to enter. The greater moment of the counterpoise enables it to raise the piece into battery. The latter can be stopped and held in any position by closing the by-pass valve.

26. The piece is hauled down into the loading position by hand, for drill or cleaning, by blocks and falls attached to the upper ends of the rotating arms and to rings on the cheek plates.

D. W. FLAGLER,
*Brigadier-General, Chief of Ordnance.*

**ORDNANCE OFFICE, WAR DEPARTMENT,**
*Washington, D. C., May 20, 1891.*

# APPENDIX 25.

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## *PROGRESS REPORT ON THE MANUFACTURE OF STEEL FORGINGS, ETC., AT THE MIDVALE STEEL WORKS, PHILADELPHIA, PA.*

The CHIEF OF ORDNANCE, U. S. A.,
*Washington, D. C.:*

SIR: I have the honor to submit the following report upon the operations undertaken for the Ordnance Department by the Midvale Steel Company for the part of the fiscal year ending June 30, 1891, that I have been on duty at the Midvale Steel Works.

I reported for duty at these works on November 27, 1890, under provisions of paragraph 11, S. O. 271, H. Q. A., A. G. O., dated November 19, 1890.

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*List of fabrications.*

| Date of order or contract. | Date of expiration of contract. | Fabrication. |
|---|---|---|
| Jan. 7, 1889 | Feb. 6, 1891 | 1. 29 sets of steel forgings for 12-inch B. L. R. mortars (cast-iron body). Contract extended to April 7, 1891. |
| July 25, 1889 | ....do ....... | 2. One set of steel forgings for 12-inch B. L. mortar (under provisions of above contract). |
| Oct. 18, 1890 | Apr. 8, 1891 | 3. 25 sets of steel forgings for 3.2-inch field guns. |
| Oct. 1, 1889 | Apr. 15, 1890 | 4. Casting for straining jacket for Watertown Arsenal (July 12, 1890, indefinitely extended). |
| Dec. 1, 1890 | Jan. 2, 1893 | 5. 43 sets of steel forgings for 12-inch B. L. R. mortar (cast-iron body). |
| Dec. 12, 1890 | Oct. 22, 1890 | 6. 10 sets of steel forgings for 7-inch B. L. siege howitzer. |
| Dec. 13, 1890 | Dec. 13, 1891 | 7. 218 8-inch armor-piercing steel shot. |
|  | June 5, 1892 | 8. 217 10-inch armor-piercing steel shot. |
| Mar. 11, 1891 | Immediate.. | 9. 2 8-inch projectile-heads, steel forgings, for Frankford Arsenal. |
| June 8, 1891 | Sept. 28, 1891 | 10. 16 sets of steel castings for 3.6-inch B. L. R. field-mortar carriage. |
| Do....... | Dec. 2, 1891 | 11. 25 sets of steel forgings for 3.2-inch field guns. |
| Do....... | Mar. 11, 1892 | 12. 100 8-inch armor-piercing steel shot. |
|  | Dec. 4, 1892 | 13. 205 10-inch armor-piercing steel shot. |
|  | Aug. 1, 1892 | 14. 50 12-inch armor-piercing steel shot. |
| June 15, 1891 | Aug. 16, 1892 | 15. 12 sets of steel forgings for 8-inch B. L. rifle. |
|  | June 16, 1894 | 16. 12 sets of steel forgings for 10-inch B. L. rifle. |
|  | Aug, 16, 1896 | 17. 9 sets of steel forgings for 12-inch B. L. rifle. |
| Aug. 21, 1891 | Immediate.. | 18. 4 crank castings.* |
|  |  | 19. 2 gun steel shaft forgings.* |

* For disappearing carriage, ordered by the Morgan Engineering Company.

Of the above list the following numbers have been completed: Nos. 1, 2, 3, 4, 6, 9, and 11.

The stores represented by these numbers have all been shipped to their respective destinations.

The unfinished work at the date of this report comprises Nos. 5, 7, 8, 10, 12, 13, 14, 15, 16, 17, 18, and 19, and of these no work has yet been submitted for test and inspection under headings Nos. 7, 8, 12, 13, 14, 16, 17, 18, 19.

Nos. 5 and 10 are partially completed, the latter only awaiting the completion of 3 castings to replace rejected pieces.

Under No. 15 work has just commenced.

Below will be found references to the unfinished work under appropriate headings.

## I.—12-INCH B. L. R. MORTARS (WITH CAST-IRON BODY).

### *a. Mortar forgings made under contract of January 7, 1889, and order of July 25, 1889.*

The contract above cited calls for 29 sets of 12-inch mortar forgings, and the order noted calls for 1 additional set under the provisions of the same contract, or 30 sets in all.

Of these, 22 sets were inspected and shipped by my predecessors between August 8, 1889 (date of first shipment), and November 20, 1890 (date of shipment of twenty-second set).

A large percentage of the remaining 8 sets were in course of fabrication under my immediate predecessor. The line of demarcation can not very satisfactorily be drawn in such work, since it is essentially continuous, and any division must be arbitrary.

The 8 remaining sets under this heading were shipped by me as follows:

| No. | Number of set. | Date of shipment. | Remarks. |
|---|---|---|---|
| 1 | 23d | Dec. 1, 1890 | All shipped to Builders' Iron Foundry, Providence, R. I., who have the contract for assembling. |
| 2 | 24th | Dec. 18, 1890 | |
| 3 | 25th | Dec. 26, 1890 | |
| 4 | 26th | ....do | |
| 5 | 27th | Dec. 29, 1890 | |
| 6 | 28th | Jan. 29, 1891 | |
| 7 | 29th | Mar. 30, 1891 | |
| 8 | 30th | Apr. 4, 1891 | |

Reports of the physical tests of this material have been forwarded to the Ordnance Office, but no tables of summaries have been prepared for this report, as the work was so nearly completed when the present inspector took charge.

*b. 12-inch mortar forgings made under contract of December 1, 1890.*

The total number of forgings required under this contract is 43 sets.

The contract was dated December 1, 1890, and was signed and delivered to the Midvale Steel Company on December 11, 1890.

The first shipment of incomplete sets was made April 25, 1891. The shipment of June 24, 1891, completed the first set, which was due March 3, 1891.

The shipment of October 3, 1891, completed the sixteenth set, and finished 116 cylindrical hoops towards the other sets. The status of the cylindrical hoops is shown in the following:

RÉSUMÉ OF CYLINDRICAL HOOPS.

| | | |
|---|---|---|
| Total number of cylindrical hoops required | | 430 |
| Total shipped (complete sets, 16) | 160 | |
| Total shipped (incomplete sets) | 116 | |
| Total on hand ready for shipment | 18 | |
| Total required to complete contract | *136 | |
| Total finished or in progress | | 430 |

These hoops can all be finished with ease by December 1, 1891, and unless some unforeseen accident occurs or the company delays its operations the contract should easily be concluded by the end of the present calendar year. The greatest delay has been in the trunnion and $A_5$ hoops by waiting for outside contractors to finish the large hammer.

In connection with these mortar forgings there is one fact which deserves special notice, viz: That in the early stages of the mortar work, though impeded by bad accidents and by the vexatious delays of outside contractors, the Midvale Steel Company never applied for an extension of contract, but stepped up and paid penalties on the first seven sets of forgings without a murmur, instead of squirming around to see how it could get out of its contract obligations.

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* 27 of these are $A_4$ hoops and 109 common hoops.

### II.—8-INCH STEEL RIFLES.

The following forgings have been made for the twelve 8-inch steel rifles now being made at these works, viz:

12 hinge pins.
12 breechblocks.
12 spindles.
30 gas-checks.
12 rotating rings.

The bars for the securing pins have also been prepared.

There is no delivery due under this contract until February 16, 1892, and it is expected that all the work except the tubes and jackets will be pretty well advanced by January 1, 1892. With ordinary diligence there should be no delay in the delivery of these forgings.

### III.—10-INCH AND 12-INCH STEEL RIFLES.

No forgings have yet been made, but much preliminary work has been done on the plant and tools for use in this connection.

### IV.—7-INCH B. L. SIEGE HOWITZERS.

The contract for ten sets of steel forgings for 7-inch siege howitzers was dated December 12, 1890; was received and delivered to the company December 20, 1890, and was completed May 29, 1891.

| | Days. |
|---|---|
| Total contract time | 314 |
| Total time consumed | 168 |
| Excess time to spare | 146 |

These forgings were shipped to Watervliet Arsenal.

### V.—3.2-INCH B. L. FIELD GUNS.

#### *a. Contract of October 18, 1890.*

This contract was for twenty-five sets of steel forgings for 3.2-inch field guns, consisting of twelve parts each. The following résumé gives the rate of progress in fabrication:

| | Days. |
|---|---|
| Total contract time | 170 |
| Time consumed in fabrication | 151 |
| Excess time to spare | 19 |

The shipments to Watervliet Arsenal were as follows:

| | Sets. |
|---|---|
| (1) February 3, 1891 | 5 |
| (2) February 17, 1891 | 5 |
| (3) February 27, 1891 | 5 |
| (4) March 7, 1891 | 5 |
| (5) March 20, 1891 | 5 |
| Total | 25 |

### *b. Contract of June 8, 1891.*

This contract was dated June 8, 1891; was delivered to the Midvale Steel Company on June 23, 1891, and preliminary work begun immediately. The contract was completed October 9, 1891, or four months and one day from the date of contract.

| | Days. |
|---|---|
| Total contract time allowed | 177 |
| Time consumed | 123 |
| Excess time to spare | 54 |

## VI.—8, 10, AND 12 INCH ARMOR-PIERCING SHOT.

These armor-piercing projectiles will be made by the Holtzer process. The Midvale Steel Company has purchased the exclusive right to manufacture in this country these armor-piercing shot.

The company has been delayed, owing to the failure of a contractor to complete the erection of their new casting plant. The first lots of both 8-inch and 10-inch shot are now due. The company hopes to deliver the whole number within a reasonable time.

## VII.—3.6-INCH MORTAR CARRIAGES.

These are steel castings and were delivered within the time specified by the contract, but owing to the press of other duties were not inspected until some days later, when one elevating arc and three carriages were rejected for holes in castings, etc.

This order is so small and the castings of such a troublesome nature that lack of success in making them the first time is not a matter of surprise. The company hopes to replace the rejected castings during the present month.

## VIII.—MISCELLANEOUS.

### *a. Casting for straining jacket for Watertown Arsenal.*

This casting had been dragging along for over a year for various reasons, and was finally cast, tested, finished, and shipped March 10, 1891. There was a cavity near one end, but on consultation with the commanding officer, Watertown Arsenal, it was decided to accept it, as the defect would not seriously interfere with the objects for which the piece was designed. One of the test specimens (an inside one) was low on elastic limit, but the general physical properties of the jacket were satisfactory. Below are given the tests:

| | Elastic limit. | Tensile strength. | Elongation after rupture. |
|---|---|---|---|
| | *Pounds.* | *Pounds.* | *Per cent.* |
| Minimum standard required | 40,000 | 75,000 | 12 |
| Outside specimen | 41,000 | 89,500 | 16.3 |
| Inside specimen | 34,000 | 84,000 | 13.7 |

### *b. 8-inch projectile heads for fuse experiments.*

These were two steel forgings made for Frankford Arsenal experiments. They were forged, tested, rough-machined, and shipped to Charles J. Field, 623 Market street, Philadelphia, Pa.

The only specifications for physical qualities were that the tensile strength should not be less than 75,000 pounds per square inch. The tests are given below for middle bars (gauge length, 2 inches; diameter, 0.505 inch; area of cross section, 0.20 square inch):

*Physical qualities.*

| | Elastic limit. | Tensile strength. | Elongation. | Contraction of area. |
|---|---|---|---|---|
| | *Pounds.* | *Pounds.* | *Per cent.* | *Per cent.* |
| No. 1 | 38,000 | 84,200 | 26.80 | 43.08 |
| No. 2 | 39,000 | 84,250 | 25.20 | 41.28 |

### IX.—CRANK CASTINGS AND GUN STEEL SHAFT FORGINGS.

These were ordered by the Morgan Engineering Company for use in a disappearing carriage being constructed for the Ordnance Department. No work has yet been done.

### X.—WEIGHT OF STEEL FORGINGS, ETC.

*1. For 3.2-inch B. L. rifles.*

CONTRACT OF OCTOBER 20, 1890.

| No. of parts. | Designation. | No. made. | Aggregate weight. |
|---|---|---|---|
| | | | *Pounds.* |
| 1 | Tubes | 25 | 15,557 |
| 2 | Jackets | 25 | 10,639 |
| 3 | Trunnion hoops | 25 | 3,975 |
| 4 | Breechblocks | 25 | 974 |
| 5 | Spindles | 25 | 271 |
| 6 | Sleeves | 25 | 1,625 |
| 7 | Key rings | 25 | 362 |
| 8 | Base rings | 25 | 774 |
| 9 | Gas-checks | 50 | 75 |
| 10 | Block carriers | 25 | 504 |
| 11 | Lever handles | 25 | 137 |
| 12 | Latch covers | 25 | 32 |
| | Total | | 34,925 |
| | CONTRACT OF JUNE 8, 1891. | | |
| 1 | Tubes | 25 | 15,608 |
| 2 | Jackets with trunnions | 25 | 14,581 |
| 3 | Breechblocks | 25 | 969 |
| 4 | Spindles | 25 | 308 |
| 5 | Block carriers | 25 | 519 |
| 6 | Gas-checks | 50 | 90 |
| 7 | Lever handles | 25 | 147 |
| 8 | Lever handle pins | 25 | 52 |
| 9 | Nuts | 25 | 14 |
| | Total | | 32,288 |

| | Pounds. |
|---|---|
| Total weight of forgings for 3.2-inch B. L. rifle, contract of October 20, 1890 | 34,925 |
| Total weight of forgings for 3.2-inch B. L. rifle, contract of June 8, 1891 | 32,288 |
| Sum | 67,213 |
| Difference | 2,637 |

### 2. *For 7-inch B. L. R. siege howitzer (steel).*

CONTRACT OF DECEMBER 12, 1890.

| No. of parts. | Designation. | No. made. | Aggregate weight. |
|---|---|---|---|
| | | | *Pounds.* |
| 1 | Tubes | 10 | 22, 254 |
| 2 | Jackets | 10 | 12, 242 |
| 3 | Trunnion hoops | 10 | 8, 890 |
| 4 | Sleeves | 10 | 7, 466 |
| 5 | Block carriers | 10 | 936 |
| 6 | Spindles | 10 | 440 |
| 7 | Breechblocks | 10 | 1, 892 |
| 8 | Face plates | 10 | 582 |
| 9 | Base rings | 10 | 1, 860 |
| 10 | Key rings | 10 | 238 |
| 11 | Lever handles | 10 | 197 |
| 12 | Gas-check cup | 20 | 205 |
| 13 | Nuts | 10 | 15 |
| | Total | | 57, 217 |

### 3. *For 12-inch B. L. mortar.*

CONTRACT OF JANUARY 7, 1889.

| No. of parts. | Designation. | No. made. | Aggregate weight. |
|---|---|---|---|
| | | | *Pounds.* |
| 1 | Trunnion hoops | 8 | 19, 056 |
| 2 | Hoop $A_1$ | 8 | 9, 254 |
| 3 | Hoop $A_2$ | 8 | 7, 733 |
| 4 | Hoop $A_3$ | 8 | 6, 233 |
| 5 | Hoop $A_4$ | 8 | 6, 226 |
| 6 | Hoop $A_5$ | 8 | 6, 245 |
| 7 | Hoop $A_6$ | 8 | 6, 247 |
| 8 | Hoop $A_7$ | 8 | 6, 262 |
| 9 | Hoop $B_1$ | 8 | 5, 741 |
| 10 | Hoop $B_3$ | 8 | 8, 123 |
| 11 | Hoop $B_4$ | 8 | 8, 099 |
| 12 | Hoop $B_5$ | 8 | 8, 116 |
| 13 | Hoop $B_6$ | 8 | 8, 104 |
| 14 | Breechblocks | 8 | 6, 993 |
| 15 | Spindles | 8 | 1, 671 |
| 16 | Face plates | 8 | 2, 016 |
| 17 | Front gas-check | 5 | 290 |
| 18 | Rear gas-check | 5 | 180 |
| 19 | Transverse roller | 8 | 248 |
| 20 | Hinge pin | 8 | 184 |
| 21 | Pinions | 8 | 102 |
| | Total | | 117, 123 |

### *4. For 12-inch B. L. R. mortar.*

CONTRACT OF DECEMBER 1, 1890.

| No. of parts. | Designation. | No. made. | Aggregate weight. |
|---|---|---|---|
| | | | *Pounds.* |
| 1 | Trunnion hoops | 17 | 39,477 |
| 2 | Hoop $A_1$ | 27 | 31,427 |
| 3 | Hoop $A_2$ | 25 | 24,251 |
| 4 | Hoop $A_3$ | 31 | 25,143 |
| 5 | Hoop $A_4$ | 30 | 24,335 |
| 6 | Hoop $A_5$ | 16 | 38,045 |
| 7 | Hoop $B_1$ | 36 | 24,971 |
| 8 | Hoop $B_3$ | 29 | 26,433 |
| 9 | Hoop $B_4$ | 31 | 31,019 |
| 10 | Hoop $B_5$ | 21 | 21,982 |
| 11 | Hoop $B_6$ | 30 | 29,005 |
| 12 | Breechblocks | 20 | 17,529 |
| 13 | Spindles | 40 | 8,314 |
| 14 | Face plate | 43 | 11,121 |
| 15 | Hinge blocks | 43 | 7,917 |
| 16 | Hinge pins | 43 | 970 |
| 17 | Transverse rollers | 43 | 1,303 |
| 18 | Front gas-check | 28 | 1,625 |
| 19 | Rear gas-checks | 28 | 1,008 |
| 20 | Pinions | 43 | 568 |
| | Total | | 366,443 |

### *5. Recapitulation of weights.*

| Forgings for— | Total weight (pounds). |
|---|---|
| 3.2-inch B. L. rifle | 67,213 |
| 7-inch B. L. howitzer | 57,217 |
| 12-inch B. L. mortar (contract of January 7, 1889) | 117,123 |
| 12-inch B. L. mortar (contract of December 1, 1890) | 366,443 |
| Total weight of forgings | 607,996 |

### *6. Tensile tests and number of measurements required in inspection.*

| | No. of specimens. | No. of measurements. |
|---|---|---|
| For 3.2-inch B. L. rifle (contract of October 20, 1890) | 353 | 2,225 |
| For 3.2-inch B. L. rifle (contract of June 8, 1891) | 299 | 2,450 |
| For 7-inch B. L. howitzer | 188 | 930 |
| For 12-inch B. L. mortar (contract of January 7, 1889) | (*) | 1,502 |
| For 12-inch B. L. mortar (contract of December 1, 1890) | 773 | 5,699 |
| Total | 1,613 | 12,806 |

* Not counted.

The above table does not include the specimens tested on the 8 sets of mortar forgings under the old contract, the minimum number of which is 200, assuming that all possess the requirements of the specifications. This would make a total of at least 1,813 specimens tested.

## XI.—REMARKS.

The foregoing report gives but a feeble idea of the labor that has been done in connection with the procurement of these forgings. The physical labor required to do this work as it should be done is such as to tax the strength and endurance of the inspectors to the fullest extent.

The requirements of the specifications are rigid and render the duty laborious and unremitting, but I am not prepared to recommend any relaxation in the requirements.

The clerical labor is an important factor so far as time is concerned, since in addition to the minute daily records of fabrication absolutely necessary to follow the work understandingly, test reports must be computed and copied, the permanent records must be kept up, and all miscellaneous correspondence indexed, briefed, copied, and answered.

Office work is continually interrupted by calls to lay off specimens, to verify tensile tests, to transfer marks on specimens or on work being machined, to witness the casting of ingots, the forging, the rolling, the oil-tempering, or the annealing.

It is very difficult to get sufficient time to make reports, as the current work absorbs every moment. This will account for the delay in transmitting this report; every thing has been sacrificed to getting out the work without unnecessary delay.

A portion of our time has been taken from our duties here for inspections at other points.

Last spring Capt. Mitcham, the assistant inspector here, was on inspection duty at Phœnixville, and the inspector had work from March 4 to May 4, 1891, at Thurlow, Pa., and is now on inspection duty at Phœnixville, Pa., and at Pottstown, Pa., a few miles beyond where part of the work is done.

Very respectfully, your obedient servant,

D. A. LYLE,
*Captain, Ord. Dept., U. S. Army, Inspector.*

PHILADELPHIA, PA.,
*October 19, 1891.*

(7083–'91.)

*The Midvale Steel Works.—Tensile tests for 3.2-inch B. L. steel field gun*—Continued.

TABLE VI.—TUBES—Continued.

| Midvale No. | Marks on specimens. | Elastic limit per square inch of original section. | Ultimate strength per square inch of original section. | Elongation per inch under stress at elastic limit. | Ultimate elongation after rupture, per cent of original length. | Reduction in area after rupture, per cent of original section. | Position of rupture. | Remarks relative to acceptance, rejection, retreatment, etc. |
|---|---|---|---|---|---|---|---|---|
| | | *Pounds.* | *Pounds.* | | | | | |
| *4522 | 32 R 122 T B $T_1$ M | 45,000 | 80,750 | .00160 | 21.00 | 46.20 | [illegible] inch from end of specimen | Accepted. |
| 15917 | 122 T B $T_2$ M | 47,000 | 81,500 | .00125 | 30.60 | 53.07 | 1 inch from end of specimen | |
| 15918 | 122 T M $T_1$ M | 51,000 | 87,500 | .00150 | 23.00 | 36.30 | 1 inch from end of specimen | |
| 15940 | 122 T M $T_2$ M | 47,000 | 86,500 | .00135 | 22.50 | 36.00 | [illegible] inch from end of specimen | |
| 16138 | 32 R 126 T B $T_1$ M | 42,000 | 80,000 | .00125 | 20.20 | 47.18 | [illegible] inch from end of specimen | Accepted. |
| 16106 | 126 T B $T_2$ M | 41,000 | 77,500 | .00115 | 21.00 | 38.19 | [illegible] inch from end of specimen | |
| 16139 | 126 T M $T_1$ M | 48,000 | 84,500 | .00140 | 20.70 | 36.30 | [illegible] inch from end of specimen | |
| 16107 | 126 T M $T_2$ M | 44,000 | 80,000 | .00130 | 22.50 | 42.48 | 1¼ inches from end of specimen | |
| 16339 | 32 R 109 T B $T_3$ M | 48,000 | 85,000 | .00150 | 21.00 | 35.35 | 1 inch from end of specimen | Accepted. |
| 16372 | 109 T B $T_4$ M | 43,000 | 81,500 | .00165 | 21.00 | 36.64 | [illegible] inch from end of specimen | |
| 16331 | 109 T M $T_3$ M | 40,000 | 77,000 | .00130 | 23.30 | 37.24 | [illegible] inch from end of specimen | |
| 16373 | 109 T M $T_4$ M | 44,000 | 83,000 | .00130 | 21.60 | 36.00 | [illegible] inch from end of specimen | |
| 16110 | 32 R 113 T B $T_3$ M | 41,000 | 78,250 | .00130 | 23.70 | 39.44 | [illegible] inch from end of specimen | Accepted. |
| 16175 | 113 T B $T_4$ M | 42,000 | 79,500 | .00120 | 29.00 | 47.18 | [illegible] inch from end of specimen | |
| 16176 | 113 T M $T_3$ M | 40,000 | 78,500 | .00115 to .00200 | 22.50 | 36.94 | [illegible] inch from end of specimen | |
| 16113 | 113 T M $T_4$ M | 43,000 | 79,000 | .00140 | 24.00 | 36.30 | [illegible] inch from end of specimen | |
| 16140 | 32 R 114 T B $T_2$ M | 46,000 | 81,500 | .00145 | 23.50 | 44.33 | [illegible] inch from end of specimen | Accepted. |
| 16111 | 114 T B $T_3$ M | 45,000 | 81,000 | .00140 | 21.20 | 41.28 | [illegible] inch from end of specimen | |
| 16141 | 114 T M $T_2$ M | 42,000 | 78,500 | .00125 | 23.20 | 41.89 | [illegible] inch from end of specimen | |
| 16112 | 114 T M $T_3$ M | 47,000 | 83,000 | .00155 | 23.00 | 47.77 | 1 inch from end of specimen | |
| 16316 | 32 R 118 T B $T_1$ M | 43,000 | 85,000 | .00130 | 20.50 | 40.34 | [illegible] inch from end of specimen | Accepted. |
| 16353 | 118 T B $T_3$ M | 44,000 | 82,500 | .00135 | 21.00 | 35.35 | [illegible] inch from end of specimen | |
| 16317 | 118 T M $T_2$ M | 42,000 | 83,000 | .00130 | 23.40 | 43.68 | [illegible] inch from end of specimen | |
| 16352 | 118 T M $T_3$ M | 43,000 | 83,500 | .00120 | 22.90 | 43.38 | [illegible] inch from end of specimen | |
| 16318 | 32 R 121 T B $T_1$ M | 43,000 | 81,750 | .00135 | 25.00 | 35.05 | 1 inch from end of specimen | Accepted. |
| 16350 | 121 T B $T_4$ M | 41,000 | 80,000 | .00135 | 23.20 | 42.48 | [illegible] inch from end of specimen | |
| 16330 | 121 T M $T_2$ M | 42,000 | 81,500 | .00125 | 20.40 | 36.00 | [illegible] inch from end of specimen | |
| 16351 | 121 T M $T_4$ M | 43,000 | 82,000 | .00120 | 24.20 | 36.64 | [illegible] inch from end of specimen | |
| 16170 | 32 R 124 T B $T_1$ M | 47,000 | 85,250 | .00155 | 21.50 | 41.28 | 1 inch from end of specimen | Accepted. |
| 16118 | 124 T B $T_3$ M | 51,000 | 84,000 | .00160 | 22.80 | 39.14 | [illegible] inch from end of specimen | |
| 16171 | 124 T M $T_1$ M | 47,000 | 84,500 | .00150 | 20.80 | 43.08 | 1 inch from end of specimen | |
| 16119 | 124 T M $T_3$ M | 46,000 | 85,000 | .00155 | 20.83 | 38.19 | 1 inch from end of specimen | |
| 16156 | 32 R 104 T B $T_3$ M | 46,000 | 84,500 | .00150 | 24.20 | 35.70 | 1¼ inches from end of specimen | Accepted. |
| 16120 | 104 T B $T_4$ M | 47,000 | 85,500 | .00135 | 20.80 | 37.89 | [illegible] inch from end of specimen | |
| 16157 | 104 T M $T_3$ M | 44,000 | 81,000 | .00150 | 23.00 | 43.08 | [illegible] inch from end of specimen | |
| 16121 | 104 T M $T_4$ M | 44,000 | 79,000 | .00150 | 27.00 | 42.78 | [illegible] inch from end of specimen | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 16277 | 32 R 112 T B $T_3$ M | 49,000 | 88,000 | .00160 | 21.60 | 36.94 | ⅞ inch from end of specimen | Accepted. |
| 16238 | 112 T B $T_4$ M | 50,000 | 92,000 | .00160 | 21.10 | 39.14 | ⅞ inch from end of specimen | |
| 16249 | 112 T M $T_4$ M | 50,000 | 88,500 | .00145 | 21.80 | 41.89 | 1⅛ inches from end of specimen | |
| 16278 | 112 T M $T_6$ M | 48,000 | 89,500 | .00155 | 21.00 | 40.34 | ⅞ inch from end of specimen | |
| 15890 | 32 R 117 T B $T_1$ M | 49,000 | 84,000 | .00140 | 23.50 | 40.99 | 1⅛ inches from end of specimen | Accepted. |
| *4520 | 32 R 117 T B $T_2$ M | 48,000 | 85,200 | .00155 | 18.50 | 37.10 | ⅞ inch from end of specimen | |
| 15907 | 32 R 117 T M $T_1$ M | 51,000 | 88,000 | .00155 | 21.00 | 36.94 | 1⅛ inches from end of specimen | |
| 15891 | 117 T M $T_2$ M | 49,000 | 88,000 | .00165 | 21.10 | 35.70 | 1 inch from end of specimen | |
| 16108 | 32 R 108 T B $T_1$ M | 42,000 | 79,500 | .00120 | 23.20 | 42.48 | ⅞ inch from end of specimen | Accepted. |
| 16079 | 108 T B $T_2$ M | 46,000 | 82,000 | .00155 | 21.60 | 38.19 | 1 inch from end of specimen | |
| 16109 | 108 T M $T_2$ M | 45,000 | 84,500 | .00130 | 26.40 | 40.04 | ⅝ inch from end of specimen | |
| 16078 | 108 T M $T_3$ M | 41,000 | 78,500 | .00130 | 23.50 | 44.83 | 1 inch from end of specimen | |
| 16279 | 32 R 119 T B $T_2$ M | 51,000 | 90,500 | .00150 | 20.60 | 36.30 | 1 inch from end of specimen | Accepted. |
| 16250 | 119 T B $T_3$ M | 52,000 | 92,000 | .00155 | 20.30 | 35.70 | ⅞ inch from end of specimen | |
| 16239 | 119 T M $T_2$ M | 48,600 | 90,000 | .00140 | 20.60 | 36.30 | ⅞ inch from end of specimen | |
| 16285 | 119 T M $T_2$ M | 50,000 | 91,000 | .00155 | 20.50 | 33.45 | 1 inch from end of specimen | |

TABLE VII.—JACKETS.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 15681 | 32 R 103 J B $T_1$ O | 56,000 | 98,500 | .00175 | 22.20 | 41.28 | 1¼ inches from end of specimen | Accepted. |
| 15677 | 103 J B $T_2$ M | 53,000 | 97,000 | .00190 | 17.00 | 20.97 | 1 inch from end of specimen | |
| 15674 | 103 J M $T_1$ M | 55,000 | 96,500 | .00185 | 22.70 | 40.69 | 1 inch from end of specimen | |
| 15688 | 103 J M $T_2$ I | 59,000 | 100,000 | .00185 | 23.00 | 42.48 | 1⅛ inches from end of specimen | |
| 15743 | 32 R 106 J B $T_1$ O | 53,000 | 95,500 | .00190 | 21.20 | 35.70 | 1¼ inches from end of specimen | Accepted. |
| 15722 | 106 J B $T_2$ M | 52,000 | 95,000 | .00190 | 19.10 | 35.70 | ⅞ inch from end of specimen | |
| 15721 | 106 J M $T_1$ M | 52,000 | 94,000 | .00190 | 22.80 | 39.44 | 1¼ inches from end of specimen | |
| 15742 | 106 J M $T_2$ I | 56,000 | 96,500 | .00200 | 21.70 | 36.30 | 1⅛ inches from end of specimen | |
| 15745 | 32 R 107 J B $T_1$ O | 57,000 | 95,000 | .00200 | 21.90 | 40.04 | 1⅛ inches from end of specimen | Accepted. |
| 15723 | 107 J B $T_2$ M | 56,000 | 95,000 | .00200 | 19.50 | 35.35 | 1 inch from end of specimen | |
| 15719 | 107 J M $T_1$ M | 59,000 | 95,000 | .00200 | 22.30 | 41.28 | 1⅛ inches from end of specimen | |
| 15744 | 107 J M $T_2$ I | 59,000 | 96,000 | .00210 | 19.30 | 32.45 | 1 inch from end of specimen | |
| 15776 | 32 R 105 J B $T_1$ O | 53,000 | 97,000 | .00180 | 19.10 | 31.15 | 1 inch from end of specimen | Accepted. |
| 15720 | 105 J B $T_2$ M | 53,000 | 97,500 | .00175 | 18.10 | 20.62 | ¾ inch from end of specimen | |
| 15705 | 105 J M $T_1$ M | 53,000 | 96,500 | .00170 | 18.60 | 27.51 | 1 inch from end of specimen | |
| 15781 | 105 J M $T_2$ I | 55,000 | 96,500 | .00210 | 22.00 | 36.30 | ¾ inch from end of specimen | |
| 15803 | 32 R 109 J B $T_1$ O | 58,000 | 100,000 | .00180 | 18.00 | 30.15 | 1⅛ inches from end of specimen | Accepted. |
| 15778 | 109 J B $T_2$ M | 55,000 | 98,500 | .00200 | 18.60 | 30.15 | ¾ inch from end of specimen | |
| 15780 | 109 J M $T_1$ M | 54,000 | 98,000 | .00190 | 20.30 | 35.35 | 1 inch from end of specimen | |
| 15804 | 109 J M $T_2$ I | 54,000 | 99,500 | .00175 | 21.50 | 35.85 | ¾ inch from end of specimen | |
| 15792 | 32 R 108 J B $T_1$ O | 53,000 | 95,000 | .00160 | 19.60 | 36.00 | ¾ inch from end of specimen | Accepted. |
| 15758 | 108 J B $T_2$ M | 52,000 | 95,500 | .00190 | 20.30 | 32.45 | 1 inch from end of specimen | |
| *4515 | 108 J M $T_1$ M | 50,000 | 92,050 | .00165 | 23.05 | 43.30 | 1⅛ inches from end of specimen | |
| 15760 | 108 J M $T_2$ I | 54,000 | 92,500 | .00175 | 22.50 | 41.28 | 1⅛ inches from end of specimen | |
| 15820 | 32 R 111 J B $T_1$ O | 51,000 | 93,500 | .00175 | 19.00 | 36.00 | 1 inch from end of specimen | Accepted. |
| 15875 | 111 J B $T_2$ M | 51.000 | 93,500 | .00160 | 22.30 | 35.05 | 1 inch from end of specimen | |
| *4517 | 111 J B $T_1$ M | 52,000 | 92,600 | .00190 | 20.00 | 37.10 | 1¼ inches from end of specimen | |
| 15822 | 111 J M $T_2$ I | 50,000 | 90,000 | .00160 | 23.40 | 35.70 | 1¼ inches from end of specimen | |

* Watertown number.

*The Midvale Steel Works.—Tensile tests for 3.2-inch B. L. steel field gun*—Continued.

TABLE VII.—JACKETS—Continued.

| Midvale No. | Marks on specimens. | Elastic limit per square inch of original section. | Ultimate strength per square inch of original section. | Elongation per inch under stress at elastic limit. | Ultimate elongation after rupture, per cent of original length. | Reduction in area after rupture, per cent of original section. | Position of rupture. | Remarks relative to acceptance, rejection, retreatment, etc. |
|---|---|---|---|---|---|---|---|---|
| | | *Pounds.* | *Pounds.* | | | | | |
| 15879 | 32 R 113 J B $T_1$ O | 50,000 | 89,500 | .00130 | 23.10 | 44.33 | ¾ inch from end of specimen | Accepted. |
| 15870 | 113 J B $T_2$ M | 49,000 | 89,500 | .00170 | 22.60 | 39.74 | ⅞ inch from end of specimen | |
| 15871 | 113 J M $T_1$ M | 50,000 | 87,500 | .00165 | 25.00 | 46.03 | 1 inch from end of specimen | |
| *4516 | 113 J M $T_2$ I | 46,000 | 83,450 | .00155 | 24.50 | 43.30 | 1⅛ inches from end of specimen | |
| 15909 | 32 R 114 J B $T_1$ O | 52,000 | 94,000 | .00165 | 20.30 | 40.99 | 1¼ inches from end of specimen | Accepted. |
| 15970 | 114 J B $T_2$ M | 51,000 | 92,500 | .00150 | 21.00 | 37.89 | ⅛ inch from end of specimen | |
| *4523 | 114 J M $T_1$ M | 50,000 | 92,050 | .00170 | 23.50 | 43.30 | 1⅛ inches from end of specimen | |
| 15971 | 114 J M $T_2$ I | 51,000 | 91,500 | .00155 | 24.10 | 43.98 | 1 inch from end of specimen | |

[Specimens 2 inches long between shoulders, diameter 0.503 inch, and 0.20 square inch cross section. Contract of June 8, 1891.]

| Midvale No. | Marks on specimens. | Elastic limit per square inch of original section. | Ultimate strength per square inch of original section. | Elongation per inch under stress at elastic limit. | Ultimate elongation after rupture, per cent of original length. | Reduction in area after rupture, per cent of original section. | Position of rupture. | Remarks relative to acceptance, rejection, retreatment, etc. |
|---|---|---|---|---|---|---|---|---|
| 16468 | 32 R 125 J B $T_1$ O | 51,000 | 95,500 | .00190 | 20.40 | 34.09 | 1 inch from end of specimen | Accepted. |
| 16441 | 125 J B $T_2$ M | 51,000 | 96,000 | .00145 | 23.60 | 38.49 | 1 inch from end of specimen | |
| 16442 | 125 J M $T_1$ M | 49,000 | 94,500 | .00155 | 24.60 | 41.89 | 1 inch from end of specimen | |
| 16469 | 125 J M $T_2$ I | 53,000 | 96,000 | .00175 | 23.10 | 42.18 | 1¼ inches from end of specimen | |
| 16480 | 32 R 124 J B $T_1$ O | 54,000 | 97,500 | .00195 | 22.50 | 42.78 | ⅞ inch from end of specimen | Accepted. |
| 16439 | 124 J B $T_2$ M | 51,000 | 98,000 | .00165 | 20.80 | 35.70 | ¾ inch from end of specimen | |
| 16440 | 124 J M $T_1$ M | 51,000 | 97,000 | .00155 | 17.50 | 32.15 | 1 inch from end of specimen | |
| 16479 | 124 J M $T_2$ I | 58,000 | 101,500 | .00205 | 18.60 | 27.51 | ⅝ inch from end of specimen | |
| 16483 | 32 R 121 J B $T_1$ O | 53,000 | 93,500 | .00180 | 22.80 | 42.48 | ⅞ inch from end of specimen | Accepted. |
| 16434 | 121 J B $T_2$ M | 51,000 | 95,000 | .00165 | 22.80 | 43.38 | ⅞ inch from end of specimen | |
| 16435 | 121 J M $T_1$ M | 54,000 | 98,500 | .00165 | 23.70 | 42.48 | 1 inch from end of specimen | |
| 16484 | 121 J M $T_2$ I | 53,000 | 94,000 | .00190 | 23.50 | 43.08 | 1 inch from end of specimen | |
| 16504 | 32 R 122 J B $T_1$ O | 54,000 | 100,000 | .00155 | 17.50 | 31.15 | 1⅛ inches from end of specimen | Accepted. |
| 16465 | 122 J B $T_2$ M | 54,000 | 100,000 | .00200 | 19.00 | 32.45 | 1 inch from end of specimen | |
| 16450 | 122 J M $T_1$ M | 53,000 | 99,500 | .00160 | 21.20 | 36.30 | 1 inch from end of specimen | |
| 16505 | 122 J M $T_1$ I | 52,000 | 95,500 | .00155 | 22.90 | 42.78 | 1 inch from end of specimen | |
| 16497 | 32 R 123 J B $T_1$ O | 57,000 | 104,500 | .00190 | 20.40 | 32.80 | 1 inch from end of specimen | Accepted. |
| 16466 | 123 J B $T_2$ M | 55,000 | 103,000 | .00195 | 18.50 | 32.45 | 1 inch from end of specimen | |
| 16467 | 123 J M $T_1$ M | 56,000 | 101,000 | .00195 | 19.90 | 35.35 | 1 inch from end of specimen | |
| 16498 | 123 J M $T_2$ I | 57,000 | 99,500 | .00175 | 22.00 | 41.28 | 1 inch from end of specimen | |
| 16473 | 32 R 126 J B $T_1$ O | (†) | 90,000 | .00155 | 21.20 | 37.24 | ⅝ inch from end of specimen | Accepted. |
| 16443 | 126 J B $T_2$ M | 46,000 | 93,500 | .00150 | 22.00 | 40.69 | ⅞ inch from end of specimen | |
| 16444 | 126 J M $T_1$ M | 50,000 | 94,500 | .00145 | 23.30 | 39.44 | ⅞ inch from end of specimen | |
| 16472 | 126 J M $T_2$ I | 51,000 | 93,000 | .00170 | 25.30 | 45.13 | 1 inch from end of specimen | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 16597 | 32 R 127 J | B $T_1$ O | 49,000 | 92,500 | .00155 | 21.40 | 40.34 | [illegible] inch from end of specimen | Accepted. |
| 16575 | 127 J | B $T_2$ M | 48,000 | 90,000 | .00140 | 22.90 | 32.45 | 1 inch from end of specimen | |
| 16576 | 127 J | M $T_1$ M | 48,000 | 89,500 | .00145 | 25.20 | 47.77 | [illegible] inch from end of specimen | |
| 16598 | 127 J | M $T_2$ I | 51,000 | 93,000 | .00155 | 20.30 | 32.45 | [illegible] inch from end of specimen | |
| 16363 | 32 R 120 J | M $T_1$ M | 44,000 | 80,500 | .00145 | 27.60 | 43.68 | 1 inch from end of specimen | Withdrawn. |
| 16362 | 120 J | B $T_1$ O | 44,000 | 88,500 | .00145 | 23.30 | 36.94 | 1¼ inches from end of specimen | |
| 16464 | 32 R 120 J | B $T_2$ M | 52,000 | 95,500 | .00195 | 20.70 | 37.24 | 1 inch from end of specimen | Accepted. |
| 16414 | 120 J | B $T_2$ O | 50,000 | 97,000 | .00155 | 22.40 | 40.99 | [illegible] inch from end of specimen | |
| 16449 | 120 J | M $T_2$ I | 51,000 | 98,500 | .00150 | 22.70 | 40.69 | 1 inch from end of specimen | |
| 16415 | 120 J | M $T_2$ M | 51,000 | 96,000 | .00145 | 24.10 | 43.08 | 1¼ inches from end of specimen | |
| 15901 | 32 R 110 J | B $T_1$ O | 56,000 | 99,000 | .00180 | 18.30 | 37.59 | [illegible] inch from end of specimen | Accepted. |
| 15911 | 110 J | B $T_2$ M | 54,000 | 98,000 | .00170 | 18.10 | 33.76 | [illegible] inch from end of specimen | |
| 15883 | 110 J | M $T_2$ I | 52,000 | 92,500 | .00160 | 23.00 | 43.08 | 1¼ inches from end of specimen | |
| *4518 | 110 J | M $T_2$ M | 52,000 | 91,700 | .00170 | 22.50 | 43.30 | 1¼ inches from end of specimen | |
| 16470 | 32 R 119 J | B $T_1$ O | 52,000 | 95,500 | .00205 | 20.70 | 34.09 | [illegible] inch from end of specimen | Accepted. |
| 16496 | 119 J | B $T_2$ M | 51,000 | 96,000 | .00165 | 23.00 | 40.04 | [illegible] inch from end of specimen | |
| 16471 | 119 J | M $T_2$ I | 52,000 | 94,500 | .00200 | 22.60 | 42.48 | 1 inch from end of specimen | |
| 16511 | 119 J | M $T_2$ M | 52,000 | 98,000 | .00160 | 22.00 | 40.69 | 1¼ inches from end of specimen | |
| 16021 | 32 R 116 J | B $T_1$ O | 53,000 | 97,000 | .00165 | 20.00 | 36.30 | [illegible] inch from end of specimen | Accepted. |
| 16005 | 116 J | B $T_2$ M | 47,000 | 91,000 | .00155 | 22.50 | 38.84 | 1 inch from end of specimen | |
| 16006 | 116 J | M $T_1$ M | 51,000 | 94,000 | .00165 | 22.70 | 37.59 | Not taken | |
| 16044 | 116 J | M $T_2$ I | 53,000 | 94,000 | .00155 | 23.70 | 39.44 | 1 inch from end of specimen | |
| 16258 | 32 R 115 J | B $T_1$ O | 50,000 | 88,500 | .00170 | 19.30 | 35.05 | [illegible] inch from end of specimen | Accepted. |
| 16226 | 115 J | B $T_2$ M | 50,000 | 90,500 | .00160 | 20.10 | 30.50 | [illegible] inch from end of specimen | |
| 16215 | 115 J | M $T_2$ I | 54,000 | 96,000 | .00155 | 22.00 | 40.69 | 1 inch from end of specimen | |
| 16254 | 115 J | M $T_3$ M | 52,000 | 94,500 | .00155 | 8.70 | 13.03 | [illegible] inch from end of specimen. $T_4$ M was taken to replace this bar. | |
| 16290 | 115 J | M $T_4$ M | 50,000 | 95,000 | .00150 | 19.20 | 33.45 | [illegible] inch from end of specimen | |
| 16100 | 32 R 112 J | B $T_1$ O | 52,000 | 95,000 | .00185 | 21.70 | 40.99 | 1 inch from end of specimen | Accepted. |
| 16016 | 112 J | B $T_2$ M | 52,000 | 96,000 | .00175 | 19.40 | 35.35 | [illegible] inch from end of specimen | |
| 16101 | 112 J | M $T_1$ M | 52,000 | 94,500 | .00160 | 20.20 | 32.15 | 1 inch from end of specimen | |
| 16017 | 112 J | M $T_2$ I | 53,000 | 93,000 | .00165 | 23.80 | 43.96 | 1 inch from end of specimen | |
| 16871 | 32 R 128 J | M $T_1$ M | 49,000 | 98,000 | .00160 | 26.70 | 43.68 | 1¼ inches from end of specimen | Accepted. |
| 16872 | 128 J | B $T_2$ M | 51,000 | 92,000 | .00145 | 21.30 | 39.14 | [illegible] inch from end of specimen | |
| 16908 | 128 J | M $T_2$ I | 52,000 | 90,500 | .00155 | 24.30 | 40.34 | [illegible] inch from end of specimen | |
| 16904 | 128 J | B $T_1$ O | 50,000 | 91,500 | .00155 | 23.30 | 42.18 | [illegible] inch from end of specimen | |
| 16958 | 32 R 129 J | B $T_1$ O | 48,000 | 88,000 | .00185 | 21.00 | 36.30 | [illegible] inch from end of specimen | Accepted. |
| 16882 | 129 J | B $T_2$ M | 47,000 | 90,000 | .00150 | 25.20 | 45.13 | 1¼ inches from end of specimen | |
| 16918 | 129 J | M $T_1$ M | 50,000 | 91,000 | .00160 | 23.40 | 45.13 | 1 inch from end of specimen | |
| 16951 | 129 J | M $T_2$ I | 50,000 | 88,500 | .00165 | 24.60 | 45.43 | 1 inch from end of specimen | |
| 16924 | 32 R 130 J | B $T_1$ O | 47,000 | 88,000 | .00130 | 26.70 | 45.73 | 1¼ inches from end of specimen | Accepted. |
| 16941 | 130 J | B $T_2$ M | 44,000 | 87,500 | .00155 | 26.40 | 44.33 | 1 inch from end of specimen | |
| 16925 | 130 J | M $T_1$ M | 49,000 | 92,000 | .00150 | 23.60 | 38.49 | 1 inch from end of specimen | |
| 16942 | 130 J | M $T_2$ I | 52,000 | 91,000 | .00160 | 26.00 | 43.96 | 1¼ inches from end of specimen | |

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* Watertown number.

† Between 45,000 and 46,000.

*The Midvale Steel Works.—Tensile tests for 3.2-inch B. L. steel field gun*—Continued.

TABLE VIII.—BREECH MECHANISM.

| Midvale No. | Marks on specimens. | Elastic limit per square inch of original section. | Ultimate strength per square inch of original section. | Elongation per inch under stress at elastic limit. | Ultimate elongation after rupture, per cent of original length. | Reduction in area after rupture, per cent of original section. | Position of rupture. | Remarks relative to acceptance, rejection, retreatment, etc. |
|---|---|---|---|---|---|---|---|---|
| | *Gas-check cups.* | *Pounds.* | *Pounds.* | | | | | |
| 15585 | 32 R 101 G C $T_1$ M | 84,000 | 136,500 | .00235 | 14.10 | 37.24 | ⅝ inch from end of specimen | Accepted { 101 A to 105 A.<br>101 B to 105 B. |
| 15555 | 106 G C $T_1$ M | 86,000 | 136,500 | .00225 | 17.30 | 45.45 | 1⅛ inches from end of specimen | Accepted { 106 A to 110 A.<br>106 B to 110 B. |
| 15583 | 111 G C $T_1$ M | 81,000 | 134,000 | .00260 | 14.60 | 34.09 | ½ inch from end of specimen | Accepted { 111 A to 115 A.<br>111 B to 115 B. |
| 15587 | 116 G C $T_1$ M | 82,000 | 136,500 | .00260 | 15.80 | 35.05 | ⅝ inch from end of specimen | Accepted { 116 A to 120 A.<br>116 B to 120 B. |
| 15586 | 121 G C $T_1$ M | 85,000 | 137,500 | .00240 | 17.50 | 42.48 | ⅞ inch from end of specimen | Accepted { 121 A to 125 A.<br>121 B to 125 B. |
| | *Spindles.* | | | | | | | |
| 15556 | 32 R 101 Sp. $L_1$ M | 60,000 | 100,360 | .00170 | 21.40 | 53.07 | ½ inch from end of specimen | Accepted. Nos. 101 to 105, inclusive. |
| 15578 | 106 Sp. $L_1$ M | 59,000 | 97,000 | .00170 | 23.00 | 55.21 | ⅞ inch from end of specimen | Accepted. Nos. 106 to 110, inclusive. |
| 15564 | 111 Sp. $L_1$ M | 57,000 | 96,000 | .00150 | 25.00 | 55.46 | ⅞ inch from end of specimen | Accepted. Nos. 111 to 115, inclusive. |
| 15565 | 116 Sp. $L_1$ M | 57,000 | 98,500 | .00190 | 22.00 | 50.32 | ⅝ inch from end of specimen | Accepted. Nos. 116 to 120, inclusive. |
| 15579 | 121 Sp. $L_1$ M | 58,000 | 96,000 | .00160 | 25.60 | 56.51 | 1¼ inches from end of specimen | Accepted. Nos. 121 to 125, inclusive. |
| | *Lever handles.* | | | | | | | |
| 15661 | 32 R 101 L H $L_1$ M | 58,000 | 93,000 | .00205 | 26.60 | 59.86 | 1⅛ inches from end of specimen | Accepted. Nos. 101 to 112, inclusive. |
| 15640 | 113 L H $L_1$ M | 58,000 | 93,000 | .00195 | 27.50 | 60.36 | 1¼ inches from end of specimen | Accepted. Nos. 113 to 124, inclusive. |
| 15662 | 125 L H $L_1$ M | 57,000 | 92,000 | .00195 | 27.80 | 61.11 | 1 inch from end of specimen | Accepted. |
| | *Block carriers.* | | | | | | | |
| 15663 | 32 R 101 B C $T_1$ M | 49,000 | 89,500 | .00170 | 21.80 | 39.14 | ½ inch from end of specimen | Accepted. Nos. 101 to 112, inclusive. |
| 15641 | 113 B C $T_1$ M | 50,000 | 88,500 | .00165 | 21.40 | 36.64 | 1 inch from end of specimen | Accepted. Nos. 113 to 124, inclusive. |
| 15667 | 125 B C $T_1$ M | 51,000 | 88,000 | .00165 | 20.10 | 37.51 | ⅝ inch from end of specimen | Accepted. |
| | *Pins and nuts.* | | | | | | | |
| 15696 | 32 R 125 N $L_1$ M | 55,000 | 90,000 | .00170 | 26.20 | 60.86 | 1⅛ inches from end of specimen | Accepts nuts 101 to 125, inclusive. Also pins of same numbers. |

*Breechblocks.*

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 16177 | 82 R 122 B B $T_1$ M | 45,000 | 84,500 | .00150 | 18.40 | 29.15 | ⅜ inch from end of specimen | Accepted. |
| 15703 | 127 B B $T_1$ M | 49,000 | 93,000 | .00190 | 14.10 | 18.11 | 1 inch from end of specimen | Withdrawn for retreatment. |
| 15076 | 127 B B $T_2$ M | 46,000 | 84,600 | .00130 | 18.00 | 29.85 | 1 inch from end of specimen | Accepted. Nos. 123 to 126, inclusive. |
| 16841 | 128 B B $T_1$ M | 51,000 | 92,000 | .00160 | 22.80 | 35.70 | 1⅛ inches from end of specimen | Accepted. Nos. 128 to 132, inclusive. |
| 16314 | 133 B B $T_1$ M | 53,000 | 98,000 | .00160 | 22.60 | 39.44 | 1 inch from end of specimen | Accepted. Nos. 133 to 137, inclusive. |
| 16342 | 138 B B $T_1$ M | 49,000 | 89,000 | .00145 | 20.80 | 39.89 | 1 inch from end of specimen | Accepted. Nos. 138 to 141, inclusive. |
| 16348 | 146 B B $T_1$ M | 48,000 | 89,000 | .00145 | 22.40 | 36.30 | 1 inch from end of specimen | Accepted. Nos. 142 to 146, inclusive. |

## *The Midvale Steel Works.—Tensile tests for 7-inch B. L. R. howitzer (steel, siege).*

### TABLE IX.—TUBES.

[Specimens 3 inches long between shoulders, diameter 0.564 inch, and 0.25 square inch cross section.]

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 14300 | 7 H 1 T—M $T_1$ O | 51,000 | 88,800 | .00167 | 23.30 | 53.16 | 1¾ inches from end of specimen | Accepted. |
| 14268 | 7 H 1 T—M $T_2$ M | 52,000 | 91,200 | .00173 | 24.00 | 49.96 | 1⅛ inches from end of specimen | |
| 14209 | 7 H 1 T—B $T_1$ M | 45,000 | 84,000 | .00163 | 22.98 | 50.70 | 1 inch from end of specimen | |
| *4413 | 7 H 1 T—B $T_2$ I | 43,000 | 88,760 | .00157 | 23.00 | 54.60 | 1 inch from end of specimen | |
| 14329 | 7 H 2 T—M $T_1$ O | 50,000 | 88,000 | .00150 | 23.30 | 42.42 | 1⅛ inches from end of specimen | Accepted. |
| 14312 | 7 H 2 T—M $T_2$ M | 48,000 | 88,400 | .00147 | 23.90 | 45.34 | 1¼ inches from end of specimen | |
| 14311 | 7 H 2 T—B $T_1$ M | 51,000 | 89,600 | .00157 | 22.90 | 45.07 | 1⅛ inches from end of specimen | |
| 14330 | 7 H 2 T—B $T_2$ I | 54,000 | 91,600 | .00170 | 22.10 | 42.49 | 1 inch from end of specimen | |
| 14389 | 7 H 3 T—M $T_1$ O | 43,000 | 82,000 | .00153 | 25.20 | 45.34 | 1¼ inches from end of specimen | Accepted. |
| 14347 | 7 H 3 T—M $T_2$ M | 42,000 | 80,800 | .00150 | 22.00 | 36.91 | 1⅛ inches from end of specimen | |
| 14375 | 7 H 3 T—B $T_1$ M | 49,000 | 88,800 | .00153 | 19.30 | 41.88 | 1 inch from end of specimen | |
| *4504 | 7 H 3 T—B $T_2$ I | 49,000 | 85,840 | .00170 | 21.70 | 44.60 | 1⅝ inches from end of specimen | |
| 14831 | 7 H 7 T—M $T_1$ O | 53,000 | 92,000 | .00180 | 20.10 | 42.69 | 1 inch from end of specimen | Accepted. |
| 14813 | 7 H 7 T—M $T_2$ M | 49,000 | 88,800 | .00177 | 22.67 | 48.70 | 1 inch from end of specimen | |
| 14812 | 7 H 7 T—B $T_1$ M | 48,000 | 86,000 | .00160 | 21.20 | 48.44 | 1⅛ inches from end of specimen | |
| 14830 | 7 H 7 T—B $T_2$ I | 49,000 | 87,320 | .00160 | 19.07 | 44.02 | ⅜ inch from end of specimen | |
| 14833 | 7 H 8 T—M $T_1$ O | 48,000 | 86,400 | .00157 | 18.53 | 32.61 | ⅛ inch from end of specimen | Accepted. |
| 14826 | 7 H 8 T—M $T_2$ M | 45,000 | 85,200 | .00140 | 20.10 | 42.69 | 1¾ inches from end of specimen | |
| 14825 | 7 H 8 T—B $T_1$ M | 44,000 | 82,000 | .00133 | 19.86 | 35.78 | ¾ inch from end of specimen | |
| 14832 | 7 H 8 T—B $T_2$ I | 47,000 | 84,000 | .00150 | 23.20 | 41.88 | 1⅛ inches from end of specimen | |
| 14883 | 7 H 9 T—M $T_1$ O | 49,000 | 92,400 | .00170 | 20.20 | 31.43 | 1 inch from end of specimen | Accepted. |
| 14868 | 7 H 9 T—M $T_2$ M | 51,000 | 94,200 | .00150 | 20.20 | 45.07 | 1⅛ inches from end of specimen | |
| 14867 | 7 H 9 T—B $T_1$ M | 46,000 | 87,200 | .00153 | 20.90 | 44.28 | 1⅛ inches from end of specimen | |
| *4506 | 7 H 9 T—B $T_2$ I | 45,000 | 86,480 | .00157 | 20.30 | 44.60 | 1 inch from end of specimen | |
| 14898 | 7 H 5 T—M $T_1$ O | 53,000 | 88,000 | .00167 | 18.53 | 30.85 | 1¼ inches from end of specimen | Accepted. |
| 14889 | 7 H 5 T—M $T_2$ M | 51,000 | 88,000 | .00163 | 19.10 | 31.14 | 1⅛ inches from end of specimen | |
| 14890 | 7 H 5 T—B $T_2$ M | 45,000 | 84,000 | .00140 | 23.30 | 51.45 | 1¼ inches from end of specimen | |
| *4509 | 7 H 5 T—B $T_2$ I | 46,000 | 81,040 | .00147 | 24.70 | 54.60 | ⅞ inch from end of specimen | |
| 14930 | 7 H 10 T—M $T_1$ O | 47,000 | 90,800 | .00170 | 19.13 | 34.92 | 1⅝ inches from end of specimen | Accepted. |
| 14909 | 7 H 10 T—M $T_2$ M | 47,000 | 88,800 | .00150 | 20.10 | 38.86 | 1⅜ inches from end of specimen | |
| 14917 | 7 H 10 T—B $T_2$ M | 45,000 | 85,600 | .00150 | 22.90 | 45.34 | 1¼ inches from end of specimen | |
| 14929 | 7 H 10 T—B $T_2$ I | 45,000 | 86,000 | .00147 | 22.83 | 49.71 | 1¼ inches from end of specimen | |

* Watertown number.

*The Midvale Steel Works.—Tensile tests for 7-inch B. L. R. howitzer (steel, siege)*—Continued.

TABLE IX.—TUBES—Continued.

| Mid-vale No. | Marks on specimens. | Elastic limit per square inch of original section, | Ultimate strength per square inch of original section. | Elongation per inch under stress at elastic limit. | Ultimate elongation after rupture, per cent of original length. | Reduction in area after rupture, per cent of original section. | Position of rupture. | Remarks relative to acceptance, rejection, retreatment, etc. |
|---|---|---|---|---|---|---|---|---|
| | | *Pounds.* | *Pounds.* | | | | | |
| 14956 | 7 H 4 T—M $T_1$ O | 51,000 | 87,600 | .00153 | 22.53 | 53.40 | 1 inch from end of specimen | Accepted. |
| 14940 | 7 H 4 T—M $T_3$ M | 49,000 | 88,000 | .00153 | 24.90 | 46.89 | 1⅜ inches from end of specimen | |
| 14939 | 7 H 4 T—B $T_2$ M | 52,000 | 92,200 | .00167 | 21.00 | 44.28 | 1¾ inches from end of specimen | |
| 14955 | 7 H 4 T—B $T_2$ I | 53,000 | 91,200 | .00153 | 19.40 | 46.38 | 1 inch from end of specimen | |
| 14957 | 7 H 6 T—M $T_1$ O | 48,000 | 85,280 | .00160 | 22.70 | 52.19 | 1 inch from end of specimen | Accepted. |
| 14937 | 7 H 6 T—M $T_3$ M | 46,000 | 84,000 | .00163 | 22.80 | 50.70 | 1⅛ inches from end of specimen | |
| 14958 | 7 H 6 T—B $T_2$ M | 42,000 | 78,840 | .00103<br>.00207 | 25.80 | 47.92 | 1⅜ inches from end of specimen | |
| 14938 | 7 H 6 T—B $T_2$ I | 42,000 | 78,400 | .00103 | 25.83 | 48.94 | 1¼ inches from end of specimen | |

TABLE X.—JACKETS.

| Mid-vale No. | Marks on specimens. | Elastic limit per square inch of original section, | Ultimate strength per square inch of original section. | Elongation per inch under stress at elastic limit. | Ultimate elongation after rupture, per cent of original length. | Reduction in area after rupture, per cent of original section. | Position of rupture. | Remarks relative to acceptance, rejection, retreatment, etc. |
|---|---|---|---|---|---|---|---|---|
| 13951 | 7 H 1 J—M $T_1$ M | 53,000 | 96,800 | .00167 | 19.33 | 35.21 | 1⅜ inches from end of specimen | Accepted. |
| *4410 | 7 H 1 J—M $T_2$ I | 50,000 | 96,440 | .00177 | 20.70 | 36.40 | 1⅜ inches from end of specimen | |
| 13950 | 7 H 1 J—B $T_1$ O | 51,000 | 94,000 | .00167 | 17.27 | 27.87 | 1 inch from end of specimen | |
| 13986 | 7 H 1 J—B $T_2$ M | 50,000 | 93,200 | .00190 | 18.80 | 32.32 | 1¼ inches from end of specimen | |
| 13899 | 7 H 2 J—M $T_1$ M | 55,000 | 96,000 | .00163 | 21.30 | 34.64 | 1¼ inches from end of specimen | Accepted. |
| 13948 | 7 H 2 J—M $T_2$ I | 52,000 | 90,400 | .00160 | 21.60 | 38.58 | ¾ inch from end of specimen | |
| 13947 | 7 H 2 J—B $T_1$ O | 53,000 | 92,000 | .00163 | 22.80 | 44.81 | 1 inch from end of specimen | |
| 13901 | 7 H 2 J—B $T_2$ M | 53,000 | 92,000 | .00157 | 25.80 | 45.86 | 1⅜ inches from end of specimen | |
| 13802 | 7 H 3 J—M $T_1$ M | 52,000 | 95,200 | .00167 | 18.47 | 29.07 | ⅞ inch from end of specimen | Accepted. |
| 13832 | 7 H 3 J—M $T_2$ I | 52,000 | 92,000 | .00163 | 23.80 | 47.66 | 1⅛ inches from end of specimen | |
| 13845 | 7 H 3 J—B $T_1$ O | 53,000 | 96,000 | .00177 | 17.78 | 35.21 | 1⅛ inches from end of specimen | |
| 13801 | 7 H 3 J—B $T_2$ M | 52,000 | 96,800 | .00170 | 20.60 | 40.52 | ¾ inch from end of specimen | |
| 13900 | 7 H 4 J—M $T_1$ M | 52,000 | 92,400 | .00178 | 17.80 | 29.66 | 1 inch from end of specimen | Accepted. |
| 13954 | 7 H 4 J—M $T_2$ I | 55,000 | 94,000 | .00180 | 16.83 | 32.06 | ½ inch from end of specimen | |
| 13949 | 7 H 4 J—B $T_1$ O | 54,000 | 97,200 | .00160 | 20.20 | 40.79 | 1⅛ inches from end of specimen | |
| 13902 | 7 H 4 J—B $T_2$ M | 53,000 | 96,400 | .00167 | 16.20 | 28.17 | ⅝ inch from end of specimen | |
| 13753 | 7 H 5 J—M $T_1$ M | 52,000 | 100,000 | .00178 | 16.07 | 27.26 | 1¼ inches from end of specimen | Accepted. |
| 13792 | 7 H 5 J—M $T_2$ I | 54,000 | 102,400 | .00190 | 16.27 | 26.05 | 1⅜ inches from end of specimen | |
| 13793 | 7 H 5 J—B $T_1$ O | 57,000 | 196,400 | .00208 | 16.13 | 27.56 | 1⅛ inches from end of specimen | |
| 13752 | 7 H 5 J—B $T_2$ M | 58,000 | 107,600 | .00220 | 16.67 | 27.26 | 1⅜ inches from end of specimen | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 13833 | 7 H 6 J—M $T_1$ M | 52,000 | 92,400 | .00153 | 23.00 | 48.18 | 1¼ inches from end of specimen | Accepted. |
| *4403 | 7 H 6 J—M $T_2$ I | 49,000 | 92,800 | .00163 | 21.70 | 49.70 | 1 inch from end of specimen | |
| 13866 | 7 H 6 J—B $T_1$ O | 53,000 | 94,400 | .00173 | 22.57 | 51.94 | 1 inch from end of specimen | |
| 13836 | 7 H 6 J—B $T_2$ M | 50,000 | 92,000 | .00147 | 22.70 | 50.70 | 1½ inches from end of specimen | |
| 13751 | 7 H 7 J—M $T_1$ M | 49,000 | 101,200 | .00170 | 16.90 | 31.98 | 1⅜ inches from end of specimen | Accepted. |
| 13781 | 7 H 7 J—M $T_2$ I | 54,000 | 104,000 | .00180 | 16.67 | 28.77 | ⅞ inch from end of specimen | |
| 13780 | 7 H 7 J—B $T_1$ O | 53,000 | 99,600 | .00177 | 16.13 | 29.96 | ⅝ inch from end of specimen | |
| 13728 | 7 H 7 J—B $T_2$ M | 48,000 | 96,600 | .00170 | 17.53 | 36.63 | ⅝ inch from end of specimen | |
| 13755 | 7 H 10 J—M $T_1$ M | 51,000 | 97,200 | .00173 | 20.60 | 34.92 | 1½ inches from end of specimen | Accepted. |
| 13834 | 7 H 10 J—M $T_2$ I | 50,000 | 95,600 | .00163 | 18.00 | 40.52 | 1⅜ inches from end of specimen | |
| 13835 | 7 H 10 J—B $T_1$ M | 54,000 | 100,000 | .00173 | 18.70 | 33.19 | 1⅝ inches from end of specimen | |
| 13754 | 7 H 10 J—B $T_2$ O | 58,000 | 102,000 | .00200 | 16.43 | 25.74 | 1⅜ inches from end of specimen | |
| 14345 | 7 H 9 J—M $T_2$ M | 48,000 | 92,600 | .00150 | 16.70 | 37.47 | ¾ inch from end of specimen | Accepted. |
| 14371 | 7 H 9 J—M $T_2$ I | 52,000 | 93,600 | .00163 | 20.20 | 41.84 | 1 inch from end of specimen | |
| 14346 | 7 H 9 J—B $T_2$ M | 50,000 | 97,600 | .00160 | 18.13 | 30.85 | 1¼ inches from end of specimen | |
| *4414 | 7 H 9 J—B $T_1$ O | 59,000 | 101,760 | .00203 | 12.00 | 15.00 | ¾ inch from end of specimen | |
| 14415 | 7 H 9 J—B $T_2$ O | 56,000 | 100,000 | .00197 | 18.00 | 27.26 | 1½ inches from end of specimen | |
| *4415 | 7 H 8 J—M $T_2$ I | 56,000 | 99,880 | .00190 | 18.00 | 41.90 | ¾ inch from end of specimen | Accepted. |
| 14413 | 7 H 8 J—M $T_2$ M | 52,000 | 97,200 | .00173 | 19.50 | 40.25 | 1 inch from end of specimen | |
| 14454 | 7 H 8 J—B $T_1$ O | 54,000 | 96,000 | .00173 | 18.20 | 32.06 | 1½ inches from end of specimen | |
| 14414 | 7 H 8 J—B $T_4$ M | 49,000 | 91,800 | .00163 | 20.10 | 32.61 | 1¾ inches from end of specimen | |
| | *Key rings.* | | | | | | | |
| 14310 | 7 H 1 K R—$T_1$ O | 55,000 | 98,800 | .00180 | 16.20 | 42.69 | ¾ inch from end of specimen | Accepted. Also 2 to 10, inclusive. The two bars were taken from opposite ends of the same forging. |
| 14341 | 7 H 1 K R—$T_2$ M | 53,000 | 94,400 | .00167 | 17.70 | 39.96 | ¾ inch from end of specimen | |

TABLE XI.—SLEEVES.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 14267 | 7 H 1 S—$T_1$ O | 54,000 | 96,000 | .00180 | 18.40 | 39.96 | 1¼ inches from end of specimen | Accepted. |
| 14251 | 7 H 1 S—$T_2$ M | 51,000 | 95,600 | .00167 | 21.70 | 41.61 | 1¾ inches from end of specimen | |
| 14331 | 7 H 4 S—$T_1$ O | 57,000 | 101,600 | .00173 | 18.30 | 41.61 | ½ inch from end of specimen | Accepted. |
| 14302 | 7 H 4 S—$T_2$ M | 53,000 | 100,000 | .00187 | 17.50 | 38.58 | 1⅜ inches from end of specimen | |
| 14253 | 7 H 5 S—$T_1$ M | 53,000 | 98,000 | .00193 | 20.00 | 40.25 | ⅞ inch from end of specimen | Accepted. |
| 14266 | 7 H 5 S—$T_2$ I | 54,000 | 96,800 | .00183 | 18.70 | 43.32 | 1 inch from end of specimen | |
| 14364 | 7 H 6 S—$T_1$ O | 58,000 | 98,000 | .00200 | 21.00 | 46.38 | 1⅜ inches from end of specimen | Accepted. |
| 14342 | 7 H 6 S—$T_2$ M | 54,000 | 96,400 | .00177 | 20.30 | 49.20 | 1¼ inches from end of specimen | |
| 14626 | 7 H 3 S—$T_1$ O | 53,000 | 103,200 | .00227 | 16.13 | 31.14 | 1⅜ inches from end of specimen | Accepted. |
| 14587 | 7 H 3 S—$T_2$ M | 55,000 | 101,600 | .00243 | 17.07 | 32.02 | 1¼ inches from end of specimen | |
| 14653 | 7 H 8 S—$T_1$ O | 56,000 | 106,000 | .00200 | 17.33 | 31.43 | 1⅜ inches from end of specimen | Accepted. |
| 14628 | 7 H 8 S—$T_2$ M | 53,000 | 104,800 | .00173 | 15.73 | 29.66 | 1¼ inches from end of specimen | |
| 14643 | 7 H 10 S—$T_1$ O | 54,000 | 104,800 | .00193 | 15.60 | 28.17 | 1 inch from end of specimen | Accepted. |
| 14625 | 7 H 10 S—$T_2$ M | 54,000 | 102,400 | .00180 | 14.40 | 20.77 | 1¼ inches from end of specimen | |
| 14301 | 7 H 2 S—$T_2$ M | 50,000 | 90,200 | .00157<br>.00180 | 21.50 | 48.18 | 1½ inches from end of specimen | Accepted. |
| 14660 | 7 H 2 S—$T_1$ O | 55,000 | 103,600 | .00207 | 18.70 | 41.88 | 1 inch from end of specimen | |
| 14642 | 7 H 2 S—$T_2$ M | 53,000 | 100,000 | .00187 | 18.53 | 40.25 | 1½ inches from end of specimen | |

* Watertown number.

*The Midvale Steel Works.—Tensile tests for 7-inch B. L. R. howitzer (steel, siege)*—Continued.

TABLE XI.—SLEEVES—Continued.

| Midvale No. | Marks on specimens. | Elastic limit per square inch of original section. | Ultimate strength per square inch of original section. | Elongation per inch under stress at elastic limit. | Ultimate elongation after rupture, per cent of original length. | Reduction in area after rupture, per cent of original section. | Position of rupture. | Remarks relative to acceptance, rejection, retreatment, etc. |
|---|---|---|---|---|---|---|---|---|
| | | *Pounds.* | *Pounds.* | | | | | |
| 14654 | 7 H 7 S—$T_1$ O | 51,000 | 98,800 | .00173 | 18.00 | 37.19 | 1 inch from end of specimen | Accepted. |
| 14629 | 7 H 7 S—$T_2$ M | 53,000 | 97,600 | .00173 | 18.27 | 39.14 | 1⅜ inches from end of specimen | |
| 14673 | 7 H 7 S—$T_3$ M | 53,000 | 99,200 | .00220 | 17.67 | 39.14 | 1⅛ inches from end of specimen | |
| 14805 | 7 H 9 S—$T_1$ O | 56,000 | 100,800 | .00190 | 18.97 | 44.81 | 1⅜ inches from end of specimen | Accepted. |
| 14784 | 7 H 9 S—$T_2$ M | 53,000 | 96,800 | .00167<br>.00217 | 20.10 | 41.34 | 1⅛ inches from end of specimen | |

TABLE XII.—TRUNNION HOOPS.

| Midvale No. | Marks on specimens. | Elastic limit per square inch of original section. | Ultimate strength per square inch of original section. | Elongation per inch under stress at elastic limit. | Ultimate elongation after rupture, per cent of original length. | Reduction in area after rupture, per cent of original section. | Position of rupture. | Remarks relative to acceptance, rejection, retreatment, etc. |
|---|---|---|---|---|---|---|---|---|
| 14474 | 7 H 1 T H—$T_1$ O | 54,000 | 90,400 | .00187 | 22.90 | 36.91 | 1⅛ inches from end of specimen | Accepted. |
| 14459 | 7 H 1 T H—$T_2$ M | 54,000 | 91,600 | .00163 | 23.50 | 47.92 | 1⅜ inches from end of specimen | |
| 14477 | 7 H 1 T H—$T_3$ I | 55,000 | 91,800 | .00187 | 24.60 | 37.75 | 1 inch from end of specimen | |
| 14472 | 7 H 3 T H—$T_1$ O | 58,000 | 101,200 | .00167 | 18.40 | 45.07 | ¾ inch from end of specimen | Accepted. |
| 14458 | 7 H 3 T H—$T_2$ M | 54,000 | 98,800 | .00187 | 18.27 | 32.90 | 1½ inches from end of specimen | |
| 14473 | 7 H 3 T H—$T_3$ I | 59,000 | 101,000 | .00193 | 20.80 | 53.88 | 1 inch from end of specimen | |
| 14768 | 7 H 2 T H—$T_1$ O | 55,000 | 97,600 | .00184 | 21.60 | 48.18 | 1⅛ inches from end of specimen | Accepted. |
| 14754 | 7 H 2 T H—$T_2$ M | 54,000 | 97,200 | .00170 | 19.17 | 34.92 | 1 inch from end of specimen | |
| 14769 | 7 H 2 T H—$T_3$ I | 56,000 | 96,400 | .00183 | 23.40 | 54.60 | 1⅛ inches from end of specimen | |
| 14801 | 7 H 5 T H—$T_1$ O | 53,000 | 96,600 | .00180 | 18.40 | 41.34 | 1 inch from end of specimen | Accepted. |
| 14776 | 7 H 5 T H—$T_2$ M | 52,000 | 97,600 | .00180 | 17.47 | 21.41 | 1⅛ inches from end of specimen | |
| 14800 | 7 H 5 T H—$T_3$ I | 55,000 | 98,400 | .00190 | 17.67 | 46.64 | ⅝ inch from end of specimen | |
| 14785 | 7 H 6 T H—$T_1$ O | 55,000 | 99,200 | .00187 | 20.10 | 39.14 | 1⅛ inches from end of specimen | Accepted. |
| 14770 | 7 H 6 T H—$T_2$ M | 54,000 | 96,800 | .00177 | 20.50 | 37.75 | 1⅝ inches from end of specimen | |
| 14794 | 7 H 6 T H—$T_3$ I | 56,000 | 99,200 | .00208 | 21.47 | 42.95 | 1¼ inches from end of specimen | |
| 14851 | 7 H 4 T H—$T_1$ O | 59,000 | 101,000 | .00198 | 19.10 | 39.41 | 1¼ inches from end of specimen | Accepted. |
| 14865 | 7 H 4 T H—$T_4$ M | 56,000 | 100,000 | .00187 | 20.80 | 46.38 | 1⅛ inches from end of specimen | |
| 14866 | 7 H 4 T H—$T_3$ I | 59,000 | 101,200 | .00197 | 21.80 | 49.46 | 1⅝ inches from end of specimen | |
| 14877 | 7 H 7 T H—$T_1$ O | 59,000 | 105,600 | .00200 | 17.20 | 32.32 | 1 inch from end of specimen | Accepted. |
| 14863 | 7 H 7 T H—$T_2$ M | 55,000 | 103,200 | .00173 | 16.73 | 33.76 | 1 inch from end of specimen | |
| 14880 | 7 H 7 T H—$T_3$ I | 66,000 | 107,200 | .00200 | 18.40 | 39.96 | 1 inch from end of specimen | |
| 14894 | 7 H 8 T H—$T_1$ O | 59,000 | 105,600 | .00208 | 15.00 | 30.25 | ⅞ inch from end of specimen | Accepted.* |
| 14871 | 7 H 8 T H—$T_2$ M | 57,000 | 104,000 | .00200 | 18.10 | 30.65 | 1⅜ inches from end of specimen | |
| 14893 | 7 H 8 T H—$T_3$ I | 59,000 | 104,000 | .00183 | 19.10 | 35.21 | 1¼ inches from end of specimen | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 14879 | 7 H 9 T H—$T_1$ O | 59,000 | 104,000 | .00200 | 18.27 | 33.48 | 1¼ inches from end of specimen | Accepted. |
| 14864 | 7 H 9 T H—$T_2$ M | 58,000 | 103,000 | .00177 | 15.30 | 29.37 | 1¼ inches from end of specimen | |
| 14876 | 7 H 9 T H—$T_3$ I | 61,000 | 105,200 | .00190 | 15.40 | 31.14 | ¾ inch from end of specimen | |
| 14872 | 7 H 10 T H—$T_1$ O | 60,000 | 107,600 | .00210 | 16.60 | 33.19 | 1⅜ inches from end of specimen | Accepted. |
| 14855 | 7 H 10 T H—$T_2$ M | 59,000 | 107,400 | .00200 | 16.70 | 32.61 | 1⅜ inches from end of specimen | |
| 14873 | 7 H 10 T H—$T_3$ I | 60,000 | 107,600 | .00203 | 16.00 | 34.34 | 1⅜ inches from end of specimen | |

### TABLE XIII.—BREECH MECHANISM.

[Specimens 2 inches long between shoulders, diameter 0.505 inch, and 0.20 square inch cross section.]

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | *Lever handles.* | | | | | | | |
| 14111 | 7 H 1 L H—$L_1$ M | 52,000 | 87,500 | .00155 | 27.40 | 58.56 | 1¼ inches from end of specimen | Accepted. Also 2 to 5, inclusive. |
| 14132 | 7 H 6 L H—$L_1$ M | 51,000 | 85,000 | .00165 | 30.00 | 59.36 | 1 inch from end of specimen | Accepted. Also 7 to 10, inclusive. |
| | *Face plates.* | | | | | | | |
| 14131 | 7 H 6 F P—$T_1$ M | 44,000 | 78,500 | .00185 | 27.20 | 45.43 | 1 inch from end of specimen | Accepted. Also 7, 8, and 9. |
| 14453 | 7 H 1 F P—$T_2$ M | 53,000 | 87,500 | .00150 | 25.80 | 44.33 | ¾ inch from end of specimen | Accepted. |
| 14439 | 7 H 10 F P—$T_2$ M | 53,000 | 87,250 | .00150 | 24.10 | 45.13 | 1 inch from end of specimen | Accepted. Also 2 to 5, inclusive. |
| | *Block carriers.* | | | | | | | |
| 14521 | 7 H 1 B C—$T_1$ M | 48,000 | 82,500 | .00130 | 27.10 | 47.18 | 1 inch from end of specimen | Accepted. Also 2 and 3. |
| 14539 | 7 H 4 B C—$T_2$ M | 49,000 | 87,500 | .00130 | 24.70 | 41.58 | 1 inch from end of specimen | Accepted. Also 5. |
| 14540 | 7 H 6 B C—$T_1$ M | 45,000 | 82,500 | .00120 | 29.00 | 55.46 | ⅞ inch from end of specimen | Accepted. Also 7 and 8. |
| 14586 | 7 H 9 B C—$T_1$ M | 47,000 | 52,000 | .00145 | 1.50 | 1.94 | ¾ inch from end of specimen | Broke through a weld lap. Second bar taken behind and parallel to this. Also 10. |
| 14544 | 7 H 9 B C—$T_2$ M | 48,000 | 88,500 | .00145 | 22.50 | 45.73 | ⅞ inch from end of specimen | |
| | *Spindles.* | | | | | | | |
| 14208 | 7 H 1 Sp—$L_1$ M | 55,000 | 92,400 | .00145 | 27.30 | 54.11 | 1¼ inches from end of specimen | Accepted. Also 2 and 3. |
| 14223 | 7 H 4 Sp—$L_1$ M | 57,000 | 98,000 | .00170 | 25.30 | 52.52 | 1 inch from end of specimen | Accepted. Also 5 and 6. |
| 14216 | 7 H 7 Sp—$L_1$ M | 61,000 | 99,000 | .00175 | 24.30 | 55.46 | 1 inch from end of specimen | Accepted. Also 8. |
| 14217 | 7 H 10 Sp—$L_1$ M | 56,000 | 95,500 | .00165 | 25.60 | 55.21 | 1 inch from end of specimen | Accepted. Also 9. |
| | *Base rings.* | | | | | | | |
| 14304 | 7 H 1 B R—$T_1$ M | 54,000 | 95,500 | .00165 | 22.00 | 40.34 | ⅝ inch from end of specimen | Accepted. Also 2 and 3. |
| 14363 | 7 H 4 B R—$T_1$ M | 53,000 | 95,500 | .00140 | 22.50 | 42.48 | 1⅛ inches from end of specimen | Accepted. Also 5, 6, and 7. |
| 14339 | 7 H 4 B R—$T_2$ M | 54,000 | 97,500 | .00170 | 20.20 | 37.24 | 1 inch from end of specimen | |
| 14340 | 7 H 8 B R—$T_1$ M | 53,000 | 95,000 | .00175 | 23.10 | 44.88 | 1⅛ inches from end of specimen | Accepted. Also 9 and 10. |
| | *Breechblocks.* | | | | | | | |
| 14338 | 7 H 1 B B—$T_2$ M | 54,000 | 99,000 | .00155 | 18.20 | 31.80 | 1 inch from end of specimen | Accepted. Also 2 and 3. |
| 14309 | 7 H 4 B B—$T_1$ M | 53,000 | 96,000 | .00165 | 20.00 | 33.10 | 1⅛ inches from end of specimen | Accepted. Also 5 and 6. |
| 14327 | 7 H 7 B B—$T_1$ M | 50,000 | 93,500 | .00155 | 18.50 | 32.15 | ⅞ inch from end of specimen | Accepted. Also 8 and 9. |
| 14328 | 7 H 10 B B—$T_1$ M | 51,000 | 94,000 | .00160 | 18.30 | 36.30 | ⅞ inch from end of specimen | Accepted. |

*The Midvale Steel Works.—Tensile tests for 7-inch B. L. R. howitzer (steel, siege)*—Continued.

TABLE XIII.—BREECH MECHANISM—Continued.

| Midvale No. | Marks on specimens. | Elastic limit per square inch of original section. | Ultimate strength per square inch of original section. | Elongation per inch under stress at elastic limit. | Ultimate elongation after rupture, per cent of original length. | Reduction in area after rupture, per cent of original section. | Position of rupture. | Remarks relative to acceptance, rejection, retreatment, etc. |
|---|---|---|---|---|---|---|---|---|
| | *Nuts.* | *Pounds.* | *Pounds.* | | | | | |
| 14808 | 7 H 1 N—L₁ M | 58,000 | 94,000 | .00155 | 26.50 | 57.06 | 1⅛ inches from end of specimen | Accepted. Also 2 to 10, inclusive. |
| | *Gas-checks.* | | | | | | | |
| 14533 | 7 H 1 G C—T₂ M | 82,000 | 136,000 | .00220 | 12.60 | 26.46 | ⅝ inch from end of specimen | Accepted. Also 2 to 6, inclusive. |
| 14518 | 7 H 8 G C—T₁ M | 76,000 | 127,500 | .00205 | 14.40 | 21.66 | ⅜ inch from end of specimen | Accepted. Also 7 to 12, inclusive. |
| 14534 | 7 H 15 G C—T₁ M | 80,000 | 135,650 | .00220 | 6.70 | 6.99 | ⅞ inch from end of specimen | Broke through a small slag spot. A second bar taken. Accepted. Also 13 to 18, inclusive. |
| 14543 | 7 H 15 G C—T₂ M | 83.000 | 136,000 | .00220 | 12.80 | 21.66 | ⅝ inch from end of specimen | |
| 14535 | 7 H 20 G C—T₁ M | 80,000 | 137,500 | .00235 | 12.30 | 16.32 | ⅞ inch from end of specimen | Accepted. Also 19. |

*Tensile tests for 12-inch B. L. rifled mortars (cast-iron body, steel hooped).*

TABLE XIV.—TRUNNION HOOPS (B₂).

[Specimens 4 inches long between shoulders, diameter 0.564 inch, and 0.25 square inch cross section. Contract of December 1, 1890.]

| Midvale No. | Marks on specimens. | Elastic limit per square inch of original section. | Ultimate strength per square inch of original section. | Elongation per inch under stress at elastic limit. | Ultimate elongation after rupture, per cent of original length. | Reduction in area after rupture, per cent of original section. | Position of rupture. | Remarks relative to acceptance, rejection, retreatment, etc. |
|---|---|---|---|---|---|---|---|---|
| 14765 | 12 M R 32 T H—T₁ O | 60,000 | 112,800 | .00200 | 14.40 | 25.13 | ¾ inch from end of specimen | Accepted. |
| 14802 | 32 T H—T₂ M | 56,000 | 110,400 | .00187 | 12.55 | 20.45 | 1¼ inches from end of specimen | |
| 14795 | 32 T H—T₃ I | 62,000 | 112,800 | .00190 | 15.30 | 28.76 | 1 inch from end of specimen | |
| 15302 | 12 M R 33 T H—T₁ O | 55,000 | 103,600 | .00170 | 16.20 | 35.78 | 2 inches from end of specimen | Accepted. |
| 15291 | 33 T H—T₂ M | 53,000 | 103,200 | .00162 | 15.00 | 30.85 | 1 inch from end of specimen | |
| 15303 | 33 T H—T₃ I | 55,000 | 104,000 | .00175 | 16.30 | 29.66 | 1⅝ inches from end of specimen | |
| 15410 | 12 M R 34 T H—T₁ O | 56,000 | 103,600 | .00177 | 19.40 | 38.86 | 2 inches from end of specimen | Accepted. |
| 15382 | 34 T H—T₂ M | 58,000 | 107,200 | .00167 | 14.40 | 29.96 | 1¼ inches from end of specimen | |
| 15411 | 34 T H—T₃ I | 58,000 | 105,600 | .00185 | 16.20 | 36.06 | 1 inch from end of specimen | |
| 15440 | 12 M R 35 T H—T₁ O | 56,000 | 108,000 | .00180 | 15.00 | 30.25 | 1⅛ inches from end of specimen | Not accepted on these tests. |
| 15414 | 35 T H—T₂ M | 57,000 | 108,800 | .00180 | 13.45 | 24.20 | 1⅛ inches from end of specimen | |
| 15439 | 35 T H—T₃ I | 64,000 | 112,600 | .00205 | 9.10 | 9.69 | ¼ inch from end of specimen | |
| 15553 | 35 T H—T₄ O | 55,000 | 100,000 | .00175 | 20.30 | 46.64 | 2 inches from end of specimen | Accepted. |
| 15494 | 35 T H—T₅ M | 55,000 | 103,600 | .00167 | 15.00 | 22.34 | 1¾ inches from end of specimen | |
| 15516 | 35 T H—T₆ I | 59,000 | 102,800 | .00182 | 17.90 | 44.02 | 1 inch from end of specimen | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 15487 | 12 M R 87 T H—$T_1$ O | 56,000 | 100,600 | .00177 | 15.40 | 29.07 | 1⅜ inches from end of specimen | Accepted. |
| 15476 | 87 T H—$T_2$ M | 56,000 | 108,800 | .00180 | 15.00 | 24.82 | 1¾ inches from end of specimen | |
| 15488 | 87 T H—$T_3$ I | 54,000 | 109,200 | .00172 | 14.20 | 30.25 | 2 inches from end of specimen | |
| 15606 | 12 M R 39 T H—$T_1$ O | 52,000 | 103,200 | .00172 | 15.30 | 27.26 | 2 inches from end of specimen | Accepted. |
| 15607 | 39 T H—$T_2$ M | 52,000 | 102,400 | .00167 | 14.80 | 32.32 | 1¼ inches from end of specimen | |
| 15596 | 39 T H—$T_3$ I | 57,000 | 106,400 | .00182 | 15.00 | 32.61 | 1 inch from end of specimen | |
| 15902 | 12 M R 40 T H—$T_1$ O | 57,000 | 102,000 | .00175 | 15.40 | 34.05 | 2¼ inches from end of specimen | Accepted. |
| 15903 | 40 T H—$T_2$ M | 57,000 | 106,400 | .00167 | 12.60 | 28.89 | 1⅜ inches from end of specimen | |
| 15884 | 40 T H—$T_3$ I | 61,000 | 103,600 | .00182 | 16.50 | 35.78 | 1¼ inches from end of specimen | |
| 15947 | 12 M R 41 T H—$T_1$ O | 55,000 | 98,400 | .00167 | 19.20 | 47.15 | 1¾ inches from end of specimen | Accepted. |
| 15931 | 41 T H—$T_2$ M | 55,000 | 98,400 | .00175 | 17.20 | 41.61 | 1 inch from end of specimen | |
| 15954 | 41 T H—$T_3$ I | 59,000 | 100,000 | .00185 | 20.60 | 49.71 | 2¼ inches from end of specimen | |
| 15969 | 12 M R 42 T H—$T_1$ O | 54,000 | 95,200 | .00165 | 21.00 | 51.26 | 2 inches from end of specimen | Accepted. |
| 15948 | 42 T H—$T_2$ M | 53,000 | 98,000 | .00155 | 17.20 | 40.52 | 1⅜ inches from end of specimen | |
| 15997 | 42 T H—$T_3$ I | 52,000 | 95,200 | .00157 | 20.40 | 47.40 | 1⅝ inches from end of specimen | |
| 16013 | 12 M R 44 T H $T_1$ O | 56,000 | 104,800 | .00180 | 15.10 | 36.63 | 2 inches from end of specimen | Accepted. |
| 16014 | 44 T H $T_2$ M | 55,000 | 104,800 | .00155 | 14.45 | 26.96 | 1¼ inches from end of specimen | |
| 15984 | 44 T H $T_3$ I | 58,000 | 106,800 | .00170 | 13.50 | 35.49 | ⅝ inch from end of specimen | |
| 16047 | 12 M R 45 T H $T_1$ O | 58,000 | 104,000 | .00187 | 14.90 | 34.92 | 1¾ inches from end of specimen | Accepted. |
| 16011 | 45 T H $T_2$ M | 50,000 | 100,800 | .00160 | 16.70 | 33.48 | 1¼ inches from end of specimen | |
| 16048 | 45 T H $T_3$ I | 53,000 | 102,800 | .00175 | 16.80 | 32.90 | 1 inch from end of specimen | |
| 16075 | 12 M R 46 T H $T_1$ O | 54,000 | 96,400 | .00182 | 17.85 | 44.28 | 1 inch from end of specimen | Accepted. |
| 16012 | 46 T H $T_2$ M | 52,000 | 100,000 | .00162 | 17.00 | 36.34 | 2 inches from end of specimen | |
| 16074 | 46 T H $TI_3$ | 58,000 | 101,200 | .00190 | 17.95 | 41.34 | 2 inches from end of specimen | |
| 16290 | 12 M R 43 T H $T_1$ O | 56,000 | 94,800 | .00175 | 12.30 | 20.15 | 1⅜ inches from end of specimen | Accepted. |
| 16173 | 43 T H $T_3$ I | 56,000 | 98,400 | .00187 | 19.10 | 52.43 | 1 inch from end of specimen | |
| 16191 | 43 T H $T_4$ M | 54,000 | 99,200 | .00160 | 19.60 | 41.61 | 1 inch from end of specimen | |
| 16409 | 12 M R 47 T H $T_1$ O | 56,000 | 107,120 | .00155 | 7.50 | 10.70 | ½ inch from end of specimen | Not accepted on these tests. |
| 16401 | 47 T H $T_2$ M | 52,000 | 104,800 | .00155 | 12.75 | 32.32 | ¾ inch from end of specimen | |
| 16410 | 47 T H $T_3$ I | 60,000 | 112,400 | .00200 | 13.85 | 31.43 | ⅝ inch from end of specimen | |
| 16588 | 12 M R 47 T H $T_4$ O | 55,000 | 101,600 | .00175 | 13.05 | 26.66 | 1¾ inches from end of specimen | Accepted. |
| 16573 | 47 T H $T_5$ M | 50,000 | 101,200 | .00165 | 17.40 | 28.47 | 1½ inches from end of specimen | |
| 16588 | 47 T H $T_6$ I | 54,000 | 103,200 | .00175 | 16.70 | 33.19 | 2 inches from end of specimen | |
| 16457 | 12 M R 48 T H $T_1$ O | 54,000 | 106,400 | .00170 | 16.55 | 32.02 | 2 inches from end of specimen | Accepted. |
| 16425 | 48 T H $T_2$ M | 50,000 | 102,800 | .00167 | 13.80 | 26.05 | 1¼ inches from end of specimen | |
| 16458 | 48 T H $T_3$ I | 55,000 | 109,600 | .00182 | 15.75 | 29.07 | 1⅜ inches from end of specimen | |
| 16547 | 12 M R 49 T H $T_1$ O | 57,000 | 105,200 | .00190 | 15.90 | 34.05 | 2⅜ inches from end of specimen | Accepted. |
| 16531 | 49 T H $T_4$ M | 51,000 | 101,600 | .00157 | 17.20 | 29.66 | 2⅜ inches from end of specimen | |
| 16548 | 49 T H $T_3$ I | 56,000 | 106,000 | .00165 | 15.50 | 31.43 | 1⅜ inches from end of specimen | |
| 16460 | 12 M R 50 T H $T_1$ O | 56,000 | 105,200 | .00177 | 15.80 | 28.17 | 2⅜ inches from end of specimen | Accepted. |
| 16426 | 50 T H $T_2$ M | 55,000 | 102.800 | .00152 | 18.50 | 37.75 | 2 inches from end of specimen | |
| 16461 | 50 T H $T_3$ I | 59,000 | 103,600 | .00207 | 17.55 | 38.58 | 1⅜ inches from end of specimen | |
| 16606 | 12 M R 51 T H $T_1$ O | 55,000 | 98,400 | .00175 | 18.80 | 40.25 | 1¼ inches from end of specimen | Accepted. |
| 16589 | 51 T H $T_2$ M | 56,000 | 102,800 | .00175 | 12.60 | 19.83 | 1¼ inches from end of specimen | |
| 16607 | 51 T H $T_3$ I | 54,000 | 100,000 | .00170 | 18.50 | 38.30 | 1½ inches from end of specimen | |
| 16928 | 12 M R 52 T H $T_1$ O | 52,000 | 100,000 | .00172 | 17.30 | 34.64 | 2⅛ inches from end of specimen | Accepted. |
| 16896 | 52 T H $T_3$ M | 54,000 | 102,800 | .00160 | 16.30 | 32.02 | 1⅝ inches from end of specimen | |
| 19929 | 52 T H $T_4$ I | 58,000 | 104,400 | .00155 | 17.00 | 42.15 | 1¾ inches from end of specimen | |
| 16927 | 12 M R 53 T H $T_1$ O | 53,000 | 102,500 | .00165 | 16.25 | 34.92 | 1⅛ inches from end of specimen | Accepted. |
| 16897 | 53 T H $T_3$ M | 58,000 | 102,400 | .00165 | 17.00 | 36.34 | 1⅝ inches from end of specimen | |
| 16923 | 53 T H $T_4$ I | 60,000 | 105,600 | .00185 | 16.30 | 39.14 | 1¾ inches from end of specimen | |

*Tensile tests for 12-inch B. L. rifled mortars (cast-iron body, steel hooped)*—**Continued.**

TABLE XIV.—TRUNNION HOOPS ($B_2$)—Continued.

| Midvale No. | Marks on specimens. | Elastic limit per square inch of original section. | Ultimate strength per square inch of original section. | Elongation per inch under stress at elastic limit. | Ultimate elongation after rupture, per cent of original length. | Reduction in area after rupture, per cent of original section. | Position of rupture. | Remarks relative to acceptance, rejection, retreatment, etc. |
|---|---|---|---|---|---|---|---|---|
| | | *Pounds.* | *Pounds.* | | | | | |
| 17027 | 12 M R 54 T H $T_1$ O | 52,000 | 98,800 | .00175 | 17.00 | 34.64 | 2 inches from end of specimen | Accepted. |
| 17006 | 54 T H $T_2$ M | 54,000 | 98,000 | .00162 | 19.40 | 45.86 | 2 inches from end of specimen | |
| 17033 | 54 T H $T_3$ I | 55,000 | 99,200 | .00172 | 18.80 | 47.15 | 1½ inches from end of specimen | |
| 17035 | 12 M R 55 T H $T_1$ O | 56,000 | 98,000 | .00172 | 17.10 | 46.64 | 1 inch from end of specimen | Accepted. |
| 17020 | 55 T H $T_2$ M | 52,000 | 98,800 | .00165 | 19.10 | 36.91 | 1¾ inches from end of specimen | |
| 17034 | 55 T H $T_3$ I | 59,000 | 99,000 | .00172 | 19.80 | 52.19 | 1⅛ inches from end of specimen | |
| 17045 | 12 M R 56 T H $T_1$ O | 51,000 | 94,800 | .00150 | 20.30 | 48.44 | 1⅜ inches from end of specimen | Accepted. |
| 17037 | 56 T H $T_2$ M | 51,000 | 95,600 | .00160 | 18.50 | 35.21 | ⅞ inch from end of specimen | |
| 17044 | 56 T H $T_3$ I | 52,000 | 94,880 | .00155 | 21.65 | 52.19 | 1½ inches from end of specimen | |
| 17056 | 12 M R 57 T H $T_1$ O | 50,000 | 92,400 | .00160 | 22.00 | 48.70 | 1¾ inches from end of specimen | Accepted. |
| 17043 | 57 T H $T_2$ M | 51,000 | 94,800 | .00162 | 18.30 | 32.02 | 1⅝ inches from end of specimen | |
| 17057 | 57 T H $T_3$ I | 55,000 | 94,800 | .00180 | 20.50 | 53.64 | 2 inches from end of specimen | |

TABLE XV.—HOOPS $A_3$.

[Specimens 3 inches long between shoulders, diameter 0.564 inch, and 0.25 square inch cross section. Contract of December 1, 1890.]

| Midvale No. | Marks on specimens. | Elastic limit per square inch of original section. | Ultimate strength per square inch of original section. | Elongation per inch under stress at elastic limit. | Ultimate elongation after rupture, per cent of original length. | Reduction in area after rupture, per cent of original section. | Position of rupture. | Remarks relative to acceptance, rejection, retreatment, etc. |
|---|---|---|---|---|---|---|---|---|
| 14240 | 12 M R 31 $A_3$—$T_1$ O | 59,000 | 96,000 | .00182 | 17.20 | 45.84 | 1¾ inches from end of specimen | Accepted. Also 32 $A_1$. |
| 14233 | 31 $A_3$—$T_2$ M | 58,000 | 96,400 | .00182 | 19.10 | 51.94 | 2⅛ inches from end of specimen | |
| 14239 | 31 $A_3$—$T_4$ I | 55,000 | 96,000 | .00150 | 18.60 | 51.45 | 2 inches from end of specimen | |
| 14377 | 12 M R 33 $A_3$—$T_1$ O | 54,000 | 100,800 | .00172 | 18.13 | 17.91 | 1¼ inches from end of specimen | Accepted. Also 33 $A_1$. |
| 14348 | 33 $A_3$—$T_2$ M | 58,000 | 106,000 | .00182 | 14.47 | 30.55 | 1¼ inches from end of specimen | |
| 14378 | 33 $A_3$—$T_3$ I | 59,000 | 107,600 | .00190 | 13.50 | 33.76 | ⅝ inch from end of specimen | |
| 14426 | 12 M R 34 $A_3$—$T_1$ O | 60,000 | 105,600 | .00202 | 15.70 | 39.41 | 1⅛ inches from end of specimen | Accepted. |
| 14374 | 34 $A_3$—$T_2$ M | 56,000 | 102,000 | .00175 | 17.50 | 34.64 | 2 inches from end of specimen | |
| 14427 | 34 $A_3$—$T_3$ I | 56,000 | 99,600 | .00180 | 16.00 | 44.54 | 1 inch from end of specimen | |
| 14451 | 12 M R 36 $A_3$—$T_1$ O | 57,000 | 100,000 | .00177 | 17.60 | 39.69 | 2 inches from end of specimen | Accepted. Also 34 $A_1$. |
| 14401 | 36 $A_3$—$T_2$ M | 58,000 | 100,000 | .00180 | 18.30 | 44.28 | 1¾ inches from end of specimen | |
| 14452 | 36 $A_3$—$T_3$ I | 55,000 | 96,000 | .00180 | 20.50 | 51.45 | 2¼ inches from end of specimen | |
| 14428 | 12 M R 35 $A_3$—$T_1$ O | 61,000 | 109,200 | .00200 | 18.50 | 22.34 | 2⅛ inches from end of specimen | Accepted. Also 35 $A_1$. |
| 14379 | 35 $A_3$—$T_2$ M | 54,000 | 104,400 | .00170 | 13.10 | 29.66 | 1 inch from end of specimen | |
| 14427 | 35 $A_3$—$T_3$ I | 61,000 | 108,400 | .00197 | 14.60 | 34.64 | 2 inches from end of specimen | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 14456 | 12 M R 37 $A_5$—$T_1$ O | 63,000 | 105,600 | .00197 | 16.20 | 44.02 | 1 inch from end of specimen | Accepted. Also 36 $A_1$. |
| 14434 | 37 $A_5$—$T_2$ M | 62,000 | 106,600 | .00195 | 15.20 | 40.52 | 1¼ inches from end of specimen | |
| 14466 | 37 $A_5$—$T_3$ I | 60,000 | 100,400 | .00180 | 19.30 | 49.46 | 1 inch from end of specimen | |
| 14497 | 12 M R 38 $A_5$—$T_1$ O | 62,000 | 109,200 | .00205 | 15.90 | 38.03 | 1½ inches from end of specimen | Accepted. Also 37 $A_1$. |
| 14455 | 38 $A_5$—$T_2$ M | 58,000 | 107,600 | .00177 | 16.70 | 36.06 | 1¾ inches from end of specimen | |
| 14498 | 38 $A_5$—$T_3$ I | 63,000 | 106,400 | .00205 | 17.50 | 43.75 | 1 inch from end of specimen | |
| 15063 | 12 M R 40 $A_5$—$T_1$ O | 61,000 | 110,800 | .00207 | 13.50 | 32.32 | 2 inches from end of specimen | Accepted. Also 38 $A_1$. No. 40 $A_5$ was changed after test to No. 47 $A_4$. |
| 15029 | 40 $A_5$—$T_2$ M | 62,000 | 113,600 | .00200 | 13.10 | 30.55 | 1½ inches from end of specimen | |
| 15066 | 40 $A_5$—$T_3$ I | 66,000 | 115,000 | .00205 | 14.20 | 31.43 | 1 inch from end of specimen | |
| 15081 | 12 M R 41 $A_5$—$T_1$ O | 58,000 | 108,000 | .00192 | 14.35 | 29.07 | ⅝ inch from end of specimen | Accepted. Also 39 $A_1$. |
| 15068 | 41 $A_5$—$T_2$ M | 57,000 | 106,000 | .00177 | 16.70 | 34.64 | 1¾ inches from end of specimen | |
| 15090 | 41 $A_5$—$T_3$ I | 62,000 | 110,400 | .00200 | 17.00 | 35.78 | 2 inches from end of specimen | |
| 15100 | 12 M R 42 $A_5$—$T_1$ O | 60,000 | 108,000 | .00182 | 13.50 | 30.85 | 1½ inches from end of specimen | Accepted. Also 40 $A_1$. |
| 15079 | 42 $A_5$—$T_2$ M | 61,000 | 107,200 | .00200 | 14.10 | 30.25 | 2¼ inches from end of specimen | |
| 15099 | 42 $A_5$—$T_3$ I | 58,000 | 103,600 | .00187 | 14.60 | 40.52 | 2 inches from end of specimen | |
| 15220 | 12 M R 43 $A_5$—$T_1$ O | 61,000 | 109,200 | .00200 | 15.50 | 37.47 | 1¼ inches from end of specimen | Accepted. Also 44 $A_1$. |
| 15189 | 43 $A_5$—$T_3$ M | 58,000 | 104,800 | .00177 | 15.60 | 35.48 | 1⅞ inches from end of specimen | |
| 15244 | 43 $A_5$—$T_4$ I | 59,000 | 102,800 | .00180 | 16.30 | 42.95 | 1⅝ inches from end of specimen | |

[Specimens 4 inches long between shoulders, diameter 0.564 inch, and 0.25 square inch cross section.]

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 15138 | 12 M R 44 $A_3$ $T_1$ O | 58,000 | 105,600 | .00177 | 17.60 | 40.52 | 1¾ inches from end of specimen | Accepted. Also No. 44 $A_1$. |
| 15106 | 44 $A_3$ $T_2$ M | 59,000 | 108,000 | .00197 | 17.20 | 40.79 | 2 inches from end of specimen | |
| 15137 | 44 $A_3$ $T_3$ I | 64,000 | 109,200 | .00205 | 16.30 | 45.60 | 1 inch from end of specimen | |
| 15150 | 12 M R 45 $A_3$ $T_1$ O | 63,000 | 108,800 | .00200 | 15.00 | 30.55 | 2 inches from end of specimen | Accepted. Also No. 42 $A_1$. |
| 15107 | 45 $A_3$ $T_2$ M | 61,000 | 107,600 | .00205 | 15.20 | 28.77 | 2 inches from end of specimen | |
| 15149 | 45 $A_3$ $T_3$ I | 62,000 | 108,800 | .00192 | 13.30 | 29.07 | ½ inch from end of specimen | |
| 15173 | 12 M R 46 $A_3$ $T_1$ O | 57,000 | 103,600 | .00185 | 18.80 | 45.34 | 2 inches from end of specimen | Accepted. Also No. 43 $A_1$. |
| 15134 | 46 $A_3$ $T_2$ M | 57,000 | 102,400 | .00187 | 18.00 | 42.15 | 2 inches from end of specimen | |
| 15161 | 46 $A_3$ $T_3$ I | 61,000 | 105,200 | .00205 | 17.60 | 43.75 | 1⅛ inches from end of specimen | |
| 16281 | 12 M R 47 $A_3$ $T_1$ O | 61,000 | 105,600 | .00185 | 18.50 | 39.14 | 1¼ inches from end of specimen | Accepted. Also No. 49 $A_1$. |
| 16282 | 47 $A_3$ $T_3$ I | 62,000 | 101,600 | .00187 | 16.50 | 48.18 | 1¾ inches from end of specimen | |
| 16256 | 47 $A_3$ $T_4$ M | 57,000 | 100,800 | .00175 | 16.45 | 32.61 | 1⅝ inches from end of specimen | |
| 16258 | 12 M R 39 $A_3$ $T_1$ O | 58,000 | 110,800 | .00177 | 14.20 | 27.87 | 1¼ inches from end of specimen | Accepted. Also No. 48 $A_1$. |
| 16172 | 39 $A_3$ $T_2$ M | 60,000 | 112,000 | .00185 | 14.50 | 28.47 | 1⅝ inches from end of specimen | |
| 16262 | 39 $A_3$ $T_3$ I | 67,000 | 113,600 | .00210 | 13.25 | 34.92 | 1⅛ inches from end of specimen | |
| 16230 | 12 M R 40 $A_3$ $T_1$ O | 56,000 | 106,800 | .00180 | 15.50 | 28.77 | 1¼ inches from end of specimen | Accepted. Also No. 46 $A_1$. |
| 16154 | 40 $A_3$ $T_2$ M | 54,000 | 105,200 | .00160 | 15.80 | 30.53 | 1¾ inches from end of specimen | |
| 16220 | 40 $A_3$ $T_3$ I | 59,000 | 108,000 | .00175 | 15.80 | 29.66 | 1⅝ inches from end of specimen | |
| 16281 | 12 M R 47 $A_3$ $T_1$ O | 61,000 | 105,600 | .00185 | 18.50 | 39.14 | 1¼ inches from end of specimen | Accepted. Also No. 49 $A_1$. |
| 16283 | 47 $A_3$ $T_3$ I | 62,000 | 101,600 | .00187 | 16.50 | 48.18 | 1¾ inches from end of specimen | |
| 16256 | 47 $A_3$ $T_4$ M | 57,000 | 100,800 | .00175 | 16.45 | 32.61 | 1⅝ inches from end of specimen | |
| 16229 | 12 M R 48 $A_3$ $T_1$ O | 60,000 | 113,200 | .00187 | 14.80 | 28.17 | 2 inches from end of specimen | Accepted. Also No. 47 $A_1$. |
| 16153 | 48 $A_3$ $T_2$ M | 57,000 | 110,800 | .00187 | 14.90 | 25.43 | 2⅛ inches from end of specimen | |
| 16228 | 48 $A_3$ $T_3$ I | 58,000 | 110,000 | .00180 | 14.10 | 32.90 | 1 inch from end of specimen | |
| 16209 | 12 M R 49 $A_3$ $T_1$ O | 57,000 | 109,200 | .00182 | 13.60 | 27.87 | 1¾ inches from end of specimen | Accepted. Also No. 45 $A_1$. |
| 16174 | 49 $A_3$ $T_2$ M | 59,000 | 110,400 | .00187 | 14.20 | 26.66 | 1½ inches from end of specimen | |
| 16208 | 49 $A_3$ $T_3$ I | 62,000 | 108,800 | .00180 | 13.70 | 31.43 | 1⅜ inches from end of specimen | |

*Tensile tests for 12-inch B. L. rifled mortars (cast-iron body, steel hooped)*—Continued.

TABLE XV.—HOOPS $A_3$—Continued.

| Midvale No. | Marks on specimens. | Elastic limit per square inch of original section. | Ultimate strength per square inch of original section. | Elongation per inch under stress at elastic limit. | Ultimate elongation after rupture, per cent of original length. | Reduction in area after rupture, per cent of original section. | Position of rupture. | Remarks relative to acceptance, rejection, retreatment, etc. |
|---|---|---|---|---|---|---|---|---|
| | | *Pounds.* | *Pounds.* | | | | | |
| 16335 | 12 M R 50 $A_3$ $T_1$ O | 59,000 | 111,200 | .00182 | 15.80 | 28.47 | 1⅞ inches from end of specimen | Accepted. Also No. 51 $A_3$. |
| 16297 | 50 $A_3$ $T_2$ M | 59,000 | 109,600 | .00177 | 14.70 | 30.85 | 2 inches from end of specimen | |
| 16336 | 50 $A_3$ $T_3$ I | 56,000 | 103,600 | .00160 | 16.00 | 34.05 | 1⅝ inches from end of specimen | |
| 16394 | 12 M R 53 $A_3$ $T_1$ O | 59,000 | 102,800 | .00175 | 18.00 | 39.41 | 2⅛ inches from end of specimen | Accepted. Also No. 48 $A_3$. |
| 16386 | 53 $A_3$ $T_2$ M | 53,000 | 97,600 | .00162 | 17.90 | 40.25 | 1¾ inches from end of specimen | |
| 16399 | 53 $A_3$ $T_3$ I | 54,000 | 96,800 | .00160 | 18.80 | 46.64 | 1¾ inches from end of specimen | |
| 16309 | 12 M R 52 $A_3$ $T_1$ O | 54,000 | 97,200 | .00170 | 14.60 | 22.96 | 1⅝ inches from end of specimen | Accepted. Also No. 50 $A_3$. |
| 16284 | 52 $A_3$ $T_2$ M | 51,000 | 100,400 | .00152 | 17.30 | 43.49 | 1¾ inches from end of specimen | |
| 16311 | 52 $A_3$ $T_3$ I | 56,000 | 98,800 | .00180 | 18.00 | 42.95 | 1¾ inches from end of specimen | |
| 16400 | 12 M R 54 $A_3$ $T_1$ O | 59,000 | 102,400 | .00192 | 14.80 | 33.19 | ⅝ inch from end of specimen | Accepted. Also No. 52 $A_3$. |
| 16384 | 54 $A_3$ $T_2$ M | 58,000 | 101,600 | .00165 | 15.30 | 33.19 | 2 inches from end of specimen | |
| 16404 | 54 $A_3$ $T_3$ I | 56,000 | 98,800 | .00160 | 17.80 | 49.20 | 1 inch from end of specimen | |
| 16452 | 12 M R 55 $A_3$ $T_1$ O | 55,000 | 100,000 | .00160 | 18.10 | 41.61 | 2 inches from end of specimen | Accepted. Also No. 53 $A_3$. |
| 16406 | 55 $A_3$ $T_2$ M | 56,000 | 98,400 | .00185 | 15.50 | 25.13 | 1⅝ inches from end of specimen | |
| 16451 | 55 $A_3$ $T_3$ I | 55,000 | 97,600 | .00150 | 18.00 | 47.66 | 1¾ inches from end of specimen | |
| 16500 | 12 M R 57 $A_3$ $T_1$ O | 60,000 | 103,600 | .00182 | 16.35 | 39.69 | 1 inch from end of specimen | Accepted. Also No. 54 $A_3$. |
| 16433 | 57 $A_3$ $T_2$ M | 57,000 | 101,600 | .00187 | 17.90 | 34.64 | 1¼ inches from end of specimen | |
| 16503 | 57 $A_3$ $T_3$ I | 60,000 | 106,000 | .00185 | 17.80 | 40.25 | 1 inch from end of specimen | |
| 16571 | 12 M R 58 $A_3$ $T_1$ O | 57,000 | 100,800 | .00187 | 15.10 | 26.85 | 1¼ inches from end of specimen | Accepted. Also No. 55 $A_3$. |
| 16516 | 58 $A_3$ $T_2$ M | 57,000 | 102,800 | .00182 | 17.00 | 40.79 | 2 inches from end of specimen | |
| 16572 | 58 $A_3$ $T_3$ I | 63,000 | 105,200 | .00200 | 14.20 | 43.22 | ⅝ inch from end of specimen | |
| 16683 | 12 M R 61 $A_3$ $T_2$ M | 57,000 | 102,800 | .00177 | 18.65 | 40.52 | 1¼ inches from end of specimen | Accepted. Also No. 56 $A_3$. |
| 16711 | 61 $A_3$ $T_1$ O | 62,000 | 102,800 | .00196 | 18.20 | 44.54 | 2 inches from end of specimen | |
| 16722 | 61 $A_3$ $T_3$ I | 59,000 | 100,800 | .00175 | 19.40 | 47.66 | 1⅝ inches from end of specimen | |
| 16812 | 12 M R 62 $A_3$ $T_1$ O | 62,000 | 108,800 | .00202 | 16.50 | 31.73 | 1⅝ inches from end of specimen | Accepted. Also No. 58 $A_3$. |
| 16710 | 62 $A_3$ $T_2$ M | 57,000 | 105,600 | .00175 | 16.85 | 35.21 | 1⅝ inches from end of specimen | |
| 16813 | 62 $A_3$ $T_3$ I | 64,000 | 108,400 | .00200 | 14.50 | 39.41 | 1¼ inches from end of specimen | |
| 16726 | 12 M R 63 $A_3$ $T_1$ O | 54,000 | 102,000 | .00177 | 17.10 | 39.14 | 2⅛ inches from end of specimen | Accepted. Also No. 57 $A_3$. |
| 16707 | 63 $A_3$ $T_2$ M | 53,000 | 98,400 | .00155 | 16.40 | 38.58 | 1¼ inches from end of specimen | |
| 16728 | 63 $A_3$ $T_3$ I | 55,000 | 97,600 | .00175 | 16.65 | 44.81 | 1¾ inches from end of specimen | |
| 16617 | 12 M R 59 $A_3$ $T_1$ O | 56,000 | 106,800 | .00182 | 15.20 | 33.48 | 2 inches from end of specimen | Accepted. Also No. 52 $B_3$. |
| 16585 | 59 $A_3$ $T_2$ M | 55,000 | 104,400 | .00160 | 14.80 | 32.61 | 1⅝ inches from end of specimen | |
| 16618 | 59 $A_3$ $T_3$ I | 61,000 | 110,400 | .00182 | 14.40 | 33.48 | 2 inches from end of specimen | |
| 17007 | 12 M R 64 $A_3$ $T_1$ O | 57,000 | 98,800 | .00177 | 18.60 | 44.54 | 1¼ inches from end of specimen | Accepted. Also No. 59 $A_3$. |
| 16982 | 64 $A_3$ $T_2$ M | 57,000 | 100,000 | .00182 | 19.80 | 42.42 | 2⅛ inches from end of specimen | |
| 17008 | 64 $A_3$ $T_4$ I | 56,000 | 98,000 | .00177 | 16.80 | 39.41 | 1⅝ inches from end of specimen | |

TABLE XVI.—HOOPS $A_4$.

[Specimens 3 inches long between shoulders, diameter 0.564 inch, and 0.25 square inch cross section.]

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 14148 | 12 M R 31 $A_4$—$T_1$ O | 56,000 | 97,800 | .00175 | 17.78 | 42.15 | 2 inches from end of specimen | Accepted. |
| 14112 | 31 $A_4$—$T_2$ M | 53,000 | 96,800 | .00177 | 16.42 | 39.14 | 1½ inches from end of specimen | |
| 14161 | 31 $A_4$—$T_3$ I | 56,000 | 94,000 | .00175 | 18.70 | 56.03 | 2 inches from end of specimen | |
| 14225 | 12 M R 33 $A_4$—$T_1$ O | 57,000 | 104,000 | .00187 | 14.60 | 26.35 | 1¾ inches from end of specimen | Accepted. Also No. 31 $A_2$. |
| 14207 | 33 $A_4$—$T_2$ M | 56,000 | 102,000 | .00182 | 13.10 | 21.72 | ¾ inch from end of specimen | |
| 14218 | 33 $A_4$—$T_3$ I | 57,000 | 100,000 | .00177 | 15.60 | 41.88 | 2 inches from end of specimen | |
| 14236 | 12 M R 35 $A_4$—$T_1$ O | 55,000 | 96,000 | .00170 | 17.20 | 31.14 | 1¼ inches from end of specimen | Accepted. Also No. 32 $A_2$. |
| 14222 | 35 $A_4$—$T_2$ M | 52,000 | 94,800 | .00165 | 18.20 | 39.41 | 2 inches from end of specimen | |
| 14237 | 35 $A_4$—$T_3$ I | 56,000 | 96,000 | .00185 | 17.50 | 48.70 | 1 inch from end of specimen | |
| 14402 | 12 M R 37 $A_4$—$T_1$ O | 57,000 | 108,800 | .00180 | 16.90 | 29.07 | 2½ inches from end of specimen | Accepted. Also No. 33 $A_2$. |
| 14372 | 37 $A_4$—$T_2$ M | 58,000 | 108,400 | .00190 | 15.80 | 26.96 | 1 inch from end of specimen | |
| 14408 | 37 $A_4$—$T_3$ I | 60,000 | 109,600 | .00180 | 15.70 | 28.47 | 2½ inches from end of specimen | |
| 14449 | 12 M R 38 $A_4$—$T_1$ O | 62,000 | 105,000 | .00200 | 17.30 | 39.14 | 1¾ inches from end of specimen | Accepted. Also No. 35 $A_2$. |
| 14400 | 38 $A_4$—$T_2$ M | 60,000 | 105,600 | .00190 | 16.20 | 35.49 | 1¾ inches from end of specimen | |
| 14456 | 38 $A_4$—$T_3$ I | 63,000 | 106,000 | .00190 | 18.10 | 41.07 | 1¾ inches from end of specimen | |
| 14430 | 12 M R 39 $A_4$—$T_1$ O | 59,000 | 103,200 | .00200 | 16.90 | 41.34 | ¾ inch from end of specimen | Accepted. Also No. 34 $A_2$. |
| 14398 | 39 $A_4$—$T_2$ M | 57,000 | 102,000 | .00177 | 13.90 | 24.82 | 1½ inches from end of specimen | |
| 14431 | 39 $A_4$—$T_3$ I | 55,000 | 100,800 | .00180 | 14.20 | 40.25 | 2 inches from end of specimen | |
| 14457 | 12 M R 40 $A_4$—$T_1$ O | 54,000 | 100,000 | .00175 | 16.00 | 34.05 | 1½ inches from end of specimen | Accepted. Also No. 36 $A_2$. |
| 14435 | 40 $A_4$—$T_2$ M | 54,000 | 98,800 | .00177 | 16.70 | 35.21 | 1½ inches from end of specimen | |
| 14467 | 40 $A_4$—$T_3$ I | 57,000 | 98,800 | .00187 | 16.20 | 44.81 | ¾ inch from end of specimen | |
| 15139 | 12 M R 32 $A_4$—$T_1$ O | 62,000 | 108,000 | .00202 | 17.30 | 45.07 | 2 inches from end of specimen | Accepted. Also No. 39 $A_2$. |
| 15125 | 32 $A_4$—$T_3$ M | 58,000 | 99,200 | .00190 | 19.90 | 49.71 | 2 inches from end of specimen | |
| 15148 | 32 $A_4$—$T_4$ I | 60,000 | 101,600 | .00180 | 19.50 | 53.64 | 1½ inches from end of specimen | |
| 15193 | 12 M R 34 $A_4$—$T_1$ O | 54,000 | 103,200 | .00180 | 15.60 | 32.32 | 2 inches from end of specimen | Accepted. Also No. 41 $A_2$. |
| 15175 | 34 $A_4$—$T_3$ M | 54,000 | 101,600 | .00190 | 16.50 | 34.64 | ¾ inch from end of specimen | |
| 15192 | 34 $A_4$—$T_4$ I | 53,000 | 99,600 | .00175 | 15.80 | 37.47 | 1½ inches from end of specimen | |
| 15172 | 12 M R 36 $A_4$—$T_1$ O | 69,000 | 115,600 | .00200 | 15.90 | 38.58 | 1¾ inches from end of specimen | Accepted. Also No. 40 $A_2$. |
| 15126 | 36 $A_4$—$T_3$ M | 69,000 | 115,600 | .00230 | 16.25 | 39.41 | 1½ inches from end of specimen | |
| 15171 | 36 $A_4$—$T_4$ I | 66,000 | 111,200 | .00205 | 14.20 | 39.69 | 1¼ inches from end of specimen | |
| 15018 | 12 M R 41 $A_4$—$T_1$ M | 59,000 | 102,800 | .00195 | 16.30 | 41.61 | 2 inches from end of specimen | Accepted. Also No. 37 $B_4$. No outside bar was taken from this hoop. |
| 14975 | 41 $A_4$—$T_2$ M | 58,000 | 102,000 | .00180 | 17.00 | 41.61 | 1¾ inches from end of specimen | |
| 15023 | 41 $A_4$—$T_3$ I | 60,000 | 101,200 | .00195 | 14.80 | 32.90 | 2 inches from end of specimen | |

[Specimens 4 inches long between shoulders, diameter 0.564 inch, and 0.25 square inch cross section.]

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 15245 | 12 M R 42 $A_4$ $T_1$ O | 63,000 | 103,200 | .00200 | 16.30 | 42.15 | 2 inches from end of specimen | Accepted. Also No. 43 $A_2$. |
| 15246 | 42 $A_4$ $T_3$ M | 62,000 | 105,600 | .00200 | 16.10 | 39.14 | 1½ inches from end of specimen | |
| 15199 | 42 $A_4$ $T_4$ I | 63,000 | 106,800 | .00197 | 15.40 | 42.42 | 1¾ inches from end of specimen | |
| 15091 | 12 M R 43 $A_4$ $T_1$ O | 61,000 | 109,200 | .00205 | 15.60 | 35.78 | 1½ inches from end of specimen | Accepted. |
| 15067 | 43 $A_4$ $T_2$ M | 59,000 | 109,600 | .00197 | 14.50 | 26.96 | 2 inches from end of specimen | |
| 15092 | 43 $A_4$ $T_3$ I | 61,000 | 108,400 | .00195 | 16.50 | 36.63 | 2 inches from end of specimen | |

*Tensile tests for 12-inch B. L. rifled mortars (cast-iron body, steel hooped)*—Continued.

TABLE XVI.—HOOPS $A_4$—Continued.

| Midvale No. | Marks on specimens. | Elastic limit per square inch of original section. | Ultimate strength per square inch of original section. | Elongation per inch under stress at elastic limit. | Ultimate elongation after rupture, per cent of original length. | Reduction in area after rupture, per cent of original section. | Position of rupture. | Remarks relative to acceptance, rejection, retreatment, etc. |
|---|---|---|---|---|---|---|---|---|
| | | *Pounds.* | *Pounds.* | | | | | |
| 15094 | 12 M R 44 $A_4$ $T_1$ O | 61, 000 | 107, 600 | .00200 | 18.10 | 42.42 | 2⅛ inches from end of specimen | Accepted. Also No. 37 $A_3$. |
| 15071 | 44 $A_4$ $T_2$ M | 61, 000 | 107, 200 | .00200 | 18.50 | 44.02 | 2 inches from end of specimen | |
| 15102 | 44 $A_4$ $T_3$ I | 63, 000 | 109, 600 | .00205 | 15.60 | 40.79 | 1½ inches from end of specimen | |
| 15136 | 12 M R 45 $A_4$ $T_1$ O | 62, 000 | 110, 800 | .00205 | 13.60 | 29.37 | 1⅜ inches from end of specimen | Accepted. Also No. 38 $A_3$. |
| 15103 | 45 $A_4$ $T_2$ M | 62, 000 | 111, 200 | .00205 | 14.90 | 36.06 | 1¼ inches from end of specimen | |
| 15128 | 45 $A_4$ $T_3$ I | 63, 000 | 108 000 | .00202 | 14.80 | 39.14 | 1¾ inches from end of specimen | |
| 15202 | 12 M R 46 $A_4$ $T_1$ O | 59, 000 | 108, 000 | .00192 | 15.40 | 39.41 | 1 inch from end of specimen | Accepted. Also No. 42 $A_3$. |
| 15176 | 46 $A_4$ $T_2$ M | 58, 000 | 107, 600 | .00182 | 16.30 | 36.34 | 2 inches from end of specimen | |
| 15203 | 46 $A_4$ $T_3$ I | 63, 000 | 110, 000 | .00200 | 16.00 | 39.69 | 1¾ inches from end of specimen | |
| 16097 | 12 M R 48 $A_4$ $T_1$ O | 68, 000 | 118, 000 | .00212 | 15.75 | 32.90 | 2 inches from end of specimen | Accepted. Also No. 44 $A_3$. |
| 16073 | 48 $A_4$ $T_2$ M | 61, 000 | 110, 800 | .00192 | 14.10 | 32.61 | 2 inches from end of specimen | |
| 16098 | 48 $A_4$ $T_3$ I | 62, 000 | 111, 200 | .00195 | 14.10 | 33.48 | 2 inches from end of specimen | |
| 16148 | 12 M R 49 $A_4$ $T_1$ O | 59, 000 | 108, 400 | .00175 | 14.20 | 32.02 | 2 inches from end of specimen | Accepted. Also No. 46 $A_3$. |
| 16105 | 49 $A_4$ $T_2$ M | 55, 000 | 104, 800 | .00170 | 16.50 | 33.76 | 2¼ inches from end of specimen | |
| 16142 | 49 $A_4$ $T_3$ I | 56, 000 | 100, 000 | .00185 | 17.90 | 44.02 | 2 inches from end of specimen | |
| 16149 | 12 M R 50 $A_4$ $T_1$ O | 56, 000 | 105, 200 | .00182 | 12.20 | 15.32 | 2 inches from end of specimen | Accepted. Also No. 47 $A_3$. |
| 16099 | 50 $A_4$ $T_2$ M | 52, 000 | 98, 000 | .00165 | 17.10 | 31.76 | 1¾ inches from end of specimen | |
| 16153 | 50 $A_4$ $T_3$ I | 53, 000 | 97, 200 | .00172 | 19.30 | 44.54 | 2 inches from end of specimen | |
| 16143 | 12 M R 51 $A_4$ $T_1$ O | 57, 000 | 104, 800 | .00180 | 17.60 | 34.05 | 1½ inches from end of specimen | Accepted. Also No. 45 $A_3$. This No. was changed to No. 51 $A_3$. |
| 16103 | 51 $A_4$ $T_2$ M | 56, 000 | 104, 400 | .00180 | 15.90 | 30.85 | 1¼ inches from end of specimen | |
| 16147 | 51 $A_4$ $T_3$ I | 57, 000 | 102, 800 | .00182 | 15.50 | 35.78 | 2⅛ inches from end of specimen | |
| 16329 | 12 M R 52 $A_4$ $T_1$ O | 60, 000 | 109, 200 | .00180 | 15.50 | 33.19 | 2 inches from end of specimen | Accepted. Also No. 56 $A_3$. |
| 16257 | 52 $A_4$ $T_2$ M | 59, 000 | 108, 400 | .00187 | 15.70 | 32.61 | 2 inches from end of specimen | |
| 16334 | 52 $A_4$ $T_3$ I | 64, 000 | 110, 000 | .00190 | 15.60 | 37.47 | ¾ inch from end of specimen | |
| 16307 | 12 M R 53 $A_4$ $T_1$ O | 56, 000 | 104, 400 | .00177 | 17.70 | 35.78 | 1⅝ inches from end of specimen | Accepted. Also No. 45 $A_3$. |
| 16282 | 53 $A_4$ $T_2$ M | 60, 000 | 106, 000 | .00182 | 14.80 | 34.34 | ¾ inch from end of specimen | |
| 16306 | 53 $A_4$ $T_3$ I | 61, 000 | 105, 200 | .00195 | 12.00 | 20.77 | 1⅛ inches from end of specimen | |
| 16608 | 12 M R 54 $A_4$ $T_1$ O | 59, 000 | 101, 600 | .00175 | 17.85 | 42.95 | 1½ inches from end of specimen | Accepted. Also No. 53 $A_3$. |
| 16605 | 54 $A_4$ $T_3$ I | 53, 000 | 95, 200 | .00165 | 19.00 | 49.20 | 2 inches from end of specimen | |
| 16584 | 54 $A_4$ $T_4$ M | 53, 000 | 96, 400 | .00150 | 18.90 | 44.81 | 1¼ inches from end of specimen | |
| 16408 | 12 M R 55 $A_4$ $T_1$ O | 58, 000 | 100, 000 | .00172 | 18.90 | 42.42 | 2 inches from end of specimen | Accepted. Also No. 50 $A_3$. |
| 16385 | 55 $A_4$ $T_2$ M | 56, 000 | 98, 400 | .00175 | 17.80 | 41.61 | 1⅜ inches from end of specimen | |
| 16407 | 55 $A_4$ $T_3$ I | 59, 000 | 98, 000 | .00182 | 19.60 | 51.70 | 2⅜ inches from end of specimen | |
| 16480 | 12 M R 57 $A_4$ $T_1$ O | 56, 000 | 98, 800 | .00172 | 18.30 | 33.76 | 2 inches from end of specimen | Accepted. Also No. 51 $A_3$. |
| 16393 | 57 $A_4$ $T_2$ M | 55, 000 | 96, 400 | .00167 | 18.20 | 42.69 | 2 inches from end of specimen | |
| 16424 | 57 $A_4$ T I | 53, 000 | 96, 000 | .00157 | 18.50 | 42.95 | 1½ inches from end of specimen | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 16438 | 12 M R 58 $A_4$ | $T_1$ O | 55,000 | 102,400 | .00182 | 15.30 | 35.21 | 1⅜ inches from end of specimen | Accepted. Also No. 52 $A_2$. |
| 16341 | 58 $A_4$ | $T_2$ M | 52,000 | 96,000 | .00167 | 18.80 | 42.15 | 1⅝ inches from end of specimen | |
| 16447 | 58 $A_4$ | $T_3$ I | 54,000 | 96,000 | .00160 | 19.30 | 47.66 | 2 inches from end of specimen | |
| 16517 | 12 M R 59 $A_4$ | $T_1$ O | 59,000 | 106,800 | .00185 | 15.50 | 32.90 | 1⅝ inches from end of specimen | Accepted. Also No. 60 $A_2$. |
| 16478 | 59 $A_4$ | $T_2$ M | 52,000 | 97,600 | .00196 | 16.85 | 38.30 | 1⅞ inches from end of specimen | |
| 16518 | 59 $A_4$ | $T_3$ I | 54,000 | 96,800 | .00177 | 15.60 | 48.22 | 1⅞ inches from end of specimen | |
| 16529 | 12 M R 60 $A_4$ | $T_1$ O | 60,000 | 106,800 | .00180 | 16.00 | 33.19 | 1⅝ inches from end of specimen | Accepted. Also No. 54 $A_2$. |
| 16501 | 60 $A_4$ | $T_2$ M | 55,000 | 103,600 | .00175 | 15.90 | 31.93 | 2 inches from end of specimen | |
| 16528 | 60 $A_4$ | $T_3$ I | 61,000 | 107,000 | .00180 | 15.30 | 34.92 | 1¼ inches from end of specimen | |
| 16761 | 12 M R 56 $A_4$ | $T_1$ O | 60,000 | 103,200 | .00182 | 18.90 | 43.49 | 2 inches from end of specimen | Accepted. Also No. 56 $A_2$. |
| 16763 | 56 $A_4$ | $T_3$ I | 64,000 | 108,000 | .00185 | 16.70 | 42.69 | 1⅝ inches from end of specimen | |
| 16789 | 56 $A_4$ | $T_4$ M | 61,000 | 103,400 | .00190 | 18.70 | 43.22 | 1⅞ inches from end of specimen | |
| 16809 | 12 M R 61 $A_4$ | $T_1$ O | 54,000 | 100,000 | .00157 | 20.00 | 42.96 | 2 inches from end of specimen | Accepted. Also No. 58 $A_2$. |
| 16737 | 61 $A_4$ | $T_2$ M | 54,000 | 100,800 | .00175 | 16.70 | 41.34 | 1¾ inches from end of specimen | |
| 16810 | 61 $A_4$ | $T_3$ I | 54,000 | 99,200 | .00150 | 18.00 | 42.69 | Not taken | |
| 16858 | 12 M R 62 $A_4$ | $T_1$ O | 60,000 | 106,000 | .00170 | 15.90 | 36.06 | 1⅝ inches from end of specimen | Accepted. Also No. 59 $A_2$. |
| 16829 | 62 $A_4$ | $T_2$ M | 58,000 | 104,800 | .00185 | 15.65 | 36.63 | 2 inches from end of specimen | |
| 16859 | 62 $A_4$ | $T_3$ I | 55,000 | 99,200 | .00157 | 17.90 | 40.25 | 1⅞ inches from end of specimen | |
| 16807 | 12 M R 55 $A_2$ | $T_1$ O | 53,000 | 98,000 | .00160 | 17.70 | 41.88 | 1¼ inches from end of specimen | This hoop was originally tested as an $A_5$ hoop and was accepted; it could not be brought to size when machined and was again tested as an $A_2$ hoop. After being accepted, it was cut in two parts; these were accepted as 53 $A_2$ and 64 $A_4$. |
| 16721 | 55 $A_2$ | $T_2$ M | 53,000 | 98,400 | .00165 | 17.80 | 38.30 | 1⅜ inches from end of specimen | |
| 16808 | 55 $A_2$ | $T_3$ I | 56,000 | 100,400 | .00175 | 9.20 | 11.70 | 1 inch from end of specimen | |
| 16921 | 12 M R 63 $A_4$ | $T_1$ O | 57,000 | 103,600 | .00175 | 17.50 | 38.03 | 1⅜ inches from end of specimen | Accepted. |
| 16857 | 63 $A_4$ | $T_2$ M | 53,000 | 96,400 | .00172 | 16.75 | 40.52 | 1⅝ inches from end of specimen | |
| 16922 | 63 $A_4$ | $T_3$ I | 55,000 | 97,200 | .00172 | 19.70 | 47.92 | 2 inches from end of specimen | |

## TABLE XVII.—HOOPS $A_5$.

[Specimens 4 inches long between shoulders, diameter 0.564 inch, and 0.25 square inch cross section.]

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 15223 | 12 M R 31 $A_5$ | $T_1$ O | 57,000 | 102,000 | .00180 | 15.00 | 30.55 | 1 inch from end of specimen | Accepted. |
| 15262 | 31 $A_5$ | $T_2$ M | 59,000 | 99,200 | .00187 | 18.60 | 53.40 | 1⅝ inches from end of specimen | |
| 15265 | 31 $A_5$ | $T_4$ I | 64,000 | 108,240 | .00197 | 17.30 | 43.22 | 1⅞ inches from end of specimen | |
| 15289 | 12 M R 32 $A_5$ | $T_1$ O | 58,000 | 107,200 | .00180 | 15.50 | 31.73 | 2½ inches from end of specimen | Accepted. |
| 15280 | 32 $A_5$ | $T_2$ M | 60,000 | 107,200 | .00177 | 18.10 | 38.86 | 1¾ inches from end of specimen | |
| 15290 | 32 $A_5$ | $T_3$ I | 65,000 | 112,000 | .00200 | 15.90 | 35.78 | 2 inches from end of specimen | |
| 15664 | 12 M R 33 $A_5$ | $T_1$ O | 60,000 | 107,600 | .00200 | 12.00 | 17.59 | 1½ inches from end of specimen | Accepted. |
| 15646 | 33 $A_5$ | $T_2$ M | 56,000 | 104,600 | .00185 | 14.40 | 24.51 | 2 inches from end of specimen | |
| 15663 | 33 $A_5$ | $T_3$ I | 60,000 | 108,000 | .00170 | 14,45 | 26.05 | ¾ inch from end of specimen | |
| 15757 | 12 M R 34 $A_5$ | $T_1$ O | 55,000 | 96,400 | .00165 | 18.25 | 50.46 | 1½ inches from end of specimen | Accepted. |
| 15759 | 34 $A_5$ | $T_3$ I | 52,000 | 92,800 | .00160 | 18.60 | 57.43 | 1 inch from end of specimen | |
| 15728 | 34 $A_5$ | $T_4$ M | 52,000 | 92,000 | .00162 | 19.80 | 51.20 | 2 inches from end of specimen | |
| 15710 | 12 M R 35 $A_5$ | $T_1$ O | 53,000 | 97,400 | .00167 | 19.10 | 41.34 | 1½ inches from end of specimen | Accepted. |
| 15689 | 35 $A_5$ | $T_2$ M | 53,000 | 98,800 | .00160 | 17.90 | 35.78 | 1½ inches from end of specimen | |
| 15711 | 35 $A_5$ | $T_3$ I | 54,000 | 96,400 | .00182 | 20.30 | 45.34 | 2 inches from end of specimen | |

*The Midvale Steel Works.—Tensile tests for 7-inch B. L. R. howitzer (steel, siege)*—Continued.

TABLE XI.—SLEEVES—Continued.

| Midvale No. | Marks on specimens. | Elastic limit per square inch of original section. | Ultimate strength per square inch of original section. | Elongation per inch under stress at elastic limit. | Ultimate elongation after rupture, per cent of original length. | Reduction in area after rupture, per cent of original section. | Position of rupture. | Remarks relative to acceptance, rejection, retreatment, etc. |
|---|---|---|---|---|---|---|---|---|
| | | *Pounds.* | *Pounds.* | | | | | |
| 14654 | 7 H 7 S—T$_1$ O | 51,000 | 98,800 | .00173 | 18.00 | 37.19 | 1 inch from end of specimen | Accepted. |
| 14629 | 7 H 7 S—T$_2$ M | 53,000 | 97,600 | .00173 | 18.27 | 39.14 | 1⅜ inches from end of specimen | |
| 14673 | 7 H 7 S—T$_3$ M | 53,000 | 99,200 | .00220 | 17.67 | 39.14 | 1⅛ inches from end of specimen | |
| 14805 | 7 H 9 S—T$_1$ O | 56,000 | 100,800 | .00190 | 18.97 | 44.81 | 1⅜ inches from end of specimen | Accepted. |
| 14784 | 7 H 9 S—T$_2$ M | 53,000 | 96,800 | .00167<br>.00217 | 20.10 | 41.34 | 1⅛ inches from end of specimen | |

TABLE XII.—TRUNNION HOOPS.

| Midvale No. | Marks on specimens. | Elastic limit per square inch of original section. | Ultimate strength per square inch of original section. | Elongation per inch under stress at elastic limit. | Ultimate elongation after rupture, per cent of original length. | Reduction in area after rupture, per cent of original section. | Position of rupture. | Remarks relative to acceptance, rejection, retreatment, etc. |
|---|---|---|---|---|---|---|---|---|
| 14474 | 7 H 1 T H—T$_1$ O | 54,000 | 90,400 | .00187 | 22.90 | 36.91 | 1⅛ inches from end of specimen | Accepted. |
| 14459 | 7 H 1 T H—T$_2$ M | 54,000 | 91,600 | .00163 | 23.50 | 47.92 | 1⅜ inches from end of specimen | |
| 14477 | 7 H 1 T H—T$_3$ I | 55,000 | 91,800 | .00187 | 24.60 | 37.75 | 1 inch from end of specimen | |
| 14472 | 7 H 3 T H—T$_1$ O | 58,000 | 101,200 | .00167 | 18.40 | 45.07 | ¾ inch from end of specimen | Accepted. |
| 14458 | 7 H 3 T H—T$_2$ M | 54,000 | 98,800 | .00187 | 18.27 | 32.90 | 1½ inches from end of specimen | |
| 14473 | 7 H 3 T H—T$_3$ I | 59,000 | 101,000 | .00193 | 20.80 | 53.88 | 1 inch from end of specimen | |
| 14768 | 7 H 2 T H—T$_1$ O | 55,000 | 97,600 | .00184 | 21.60 | 48.18 | 1⅛ inches from end of specimen | Accepted. |
| 14754 | 7 H 2 T H—T$_2$ M | 54,000 | 97,200 | .00170 | 19.17 | 34.92 | 1 inch from end of specimen | |
| 14769 | 7 H 2 T H—T$_3$ I | 56,000 | 96,400 | .00183 | 23.40 | 54.60 | 1⅛ inches from end of specimen | |
| 14801 | 7 H 5 T H—T$_1$ O | 53,000 | 96,600 | .00180 | 18.40 | 41.34 | 1 inch from end of specimen | Accepted. |
| 14776 | 7 H 5 T H—T$_2$ M | 52,000 | 97,600 | .00180 | 17.47 | 21.41 | 1⅛ inches from end of specimen | |
| 14800 | 7 H 5 T H—T$_3$ I | 55,000 | 98,400 | .00190 | 17.67 | 46.64 | ⅜ inch from end of specimen | |
| 14785 | 7 H 6 T H—T$_1$ O | 55,000 | 99,200 | .00187 | 20.10 | 39.14 | 1⅛ inches from end of specimen | Accepted. |
| 14770 | 7 H 6 T H—T$_2$ M | 54,000 | 96,800 | .00177 | 20.50 | 37.75 | 1⅝ inches from end of specimen | |
| 14794 | 7 H 6 T H—T$_3$ I | 56,000 | 99,200 | .00208 | 21.47 | 42.95 | 1¼ inches from end of specimen | |
| 14851 | 7 H 4 T H—T$_1$ O | 59,000 | 101,000 | .00198 | 19.10 | 39.41 | 1¼ inches from end of specimen | Accepted. |
| 14865 | 7 H 4 T H—T$_4$ M | 56,000 | 109,000 | .00187 | 20.80 | 46.88 | 1⅛ inches from end of specimen | |
| 14866 | 7 H 4 T H—T$_3$ I | 59,000 | 101,200 | .00197 | 21.80 | 49.46 | 1⅝ inches from end of specimen | |
| 14877 | 7 H 7 T H—T$_1$ O | 59,000 | 105,600 | .00200 | 17.20 | 32.32 | 1 inch from end of specimen | Accepted. |
| 14863 | 7 H 7 T H—T$_2$ M | 55,000 | 103,200 | .00173 | 16.73 | 33.76 | 1 inch from end of specimen | |
| 14880 | 7 H 7 T H—T$_3$ I | 66,000 | 107,200 | .00200 | 18.40 | 39.90 | 1 inch from end of specimen | |
| 14894 | 7 H 8 T H—T$_1$ O | 59,000 | 105,600 | .00208 | 15.00 | 30.25 | ⅜ inch from end of specimen | Accepted.* |
| 14871 | 7 H 8 T H—T$_2$ M | 57,000 | 104,000 | .00200 | 18.10 | 30.85 | 1⅜ inches from end of specimen | |
| 14893 | 7 H 8 T H—T$_3$ I | 59,000 | 104,000 | .00183 | 19.10 | 35.21 | 1⅜ inches from end of specimen | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 14879 | 7 H 9 T H—$T_1$ O | 59,000 | 104,000 | .00200 | 18.27 | 33.48 | 1½ inches from end of specimen | Accepted. |
| 14864 | 7 H 9 T H—$T_2$ M | 58,000 | 103,000 | .00177 | 15.30 | 29.37 | 1¼ inches from end of specimen | |
| 14878 | 7 H 9 T H—$T_3$ I | 61,000 | 105,200 | .00190 | 15.40 | 31.14 | ¾ inch from end of specimen | |
| 14872 | 7 H 10 T H—$T_1$ O | 60,000 | 107,600 | .00210 | 16.60 | 33.19 | 1⅜ inches from end of specimen | Accepted. |
| 14855 | 7 H 10 T H—$T_2$ M | 59,000 | 107,400 | .00200 | 16.70 | 32.61 | 1⅜ inches from end of specimen | |
| 14873 | 7 H 10 T H—$T_3$ I | 60,000 | 107,600 | .00203 | 16.00 | 34.34 | 1⅜ inches from end of specimen | |

## TABLE XIII.—BREECH MECHANISM.

[Specimens 2 inches long between shoulders, diameter 0.505 inch, and 0.20 square inch cross section.]

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | *Lever handles.* | | | | | | | |
| 14111 | 7 H 1 L H—$L_1$ M | 52,000 | 87,500 | .00155 | 27.40 | 58.56 | 1½ inches from end of specimen | Accepted. Also 2 to 5, inclusive. |
| 14132 | 7 H 6 L H—$L_1$ M | 51,000 | 85,000 | .00165 | 30.00 | 59.36 | 1 inch from end of specimen | Accepted. Also 7 to 10, inclusive. |
| | *Face plates.* | | | | | | | |
| 14131 | 7 H 6 F P—$T_1$ M | 44,000 | 78,500 | .00135 | 27.20 | 45.43 | 1 inch from end of specimen | Accepted. Also 7, 8, and 9. |
| 14453 | 7 H 1 F P—$T_2$ M | 53,000 | 87,500 | .00150 | 25.80 | 44.33 | ¾ inch from end of specimen | Accepted. |
| 14439 | 7 H 10 F P—$T_2$ M | 53,000 | 87,250 | .00150 | 24.10 | 45.13 | 1 inch from end of specimen | Accepted. Also 2 to 5, inclusive. |
| | *Block carriers.* | | | | | | | |
| 14521 | 7 H 1 B C—$T_1$ M | 48,000 | 82,500 | .00130 | 27.10 | 47.18 | 1 inch from end of specimen | Accepted. Also 2 and 3. |
| 14539 | 7 H 4 B C—$T_2$ M | 49,000 | 87,500 | .00130 | 24.70 | 41.58 | 1 inch from end of specimen | Accepted. Also 5. |
| 14540 | 7 H 6 B C—$T_1$ M | 45,000 | 82,500 | .00120 | 29.00 | 55.46 | ⅞ inch from end of specimen | Accepted. Also 7 and 8. |
| 14536 | 7 H 9 B C—$T_1$ M | 47,000 | 52,000 | .00145 | 1.50 | 1.94 | ½ inch from end of specimen | Broke through a weld lap. Second bar taken behind and parallel to this. Also 10. |
| 14544 | 7 H 9 B C—$T_2$ M | 48,000 | 88,500 | .00145 | 22.50 | 45.73 | ⅝ inch from end of specimen | |
| | *Spindles.* | | | | | | | |
| 14208 | 7 H 1 Sp—$L_1$ M | 55,000 | 92,400 | .00145 | 27.30 | 54.11 | 1½ inches from end of specimen | Accepted. Also 2 and 3. |
| 14223 | 7 H 4 Sp—$L_1$ M | 57,000 | 98,000 | .00170 | 25.30 | 52.52 | 1 inch from end of specimen | Accepted. Also 5 and 6. |
| 14216 | 7 H 7 Sp—$L_1$ M | 61,000 | 99,000 | .00175 | 24.30 | 55.46 | 1 inch from end of specimen | Accepted. Also 8. |
| 14217 | 7 H 10 Sp—$L_1$ M | 56,000 | 95,500 | .00165 | 25.60 | 55.21 | 1 inch from end of specimen | Accepted. Also 9. |
| | *Base rings.* | | | | | | | |
| 14304 | 7 H 1 B R—$T_1$ M | 54,000 | 95,500 | .00165 | 22.00 | 40.34 | ⅝ inch from end of specimen | Accepted. Also 2 and 3. |
| 14363 | 7 H 4 B R—$T_1$ M | 58,000 | 95,500 | .00140 | 22.50 | 42.48 | 1½ inches from end of specimen | Accepted. Also 5, 6, and 7. |
| 14339 | 7 H 4 B R—$T_2$ M | 54,000 | 97,500 | .00170 | 20.20 | 37.24 | 1 inch from end of specimen | |
| 14340 | 7 H 8 B R—$T_1$ M | 53,000 | 95,000 | .00175 | 23.10 | 44.88 | 1½ inches from end of specimen | Accepted. Also 9 and 10. |
| | *Breechblocks.* | | | | | | | |
| 14338 | 7 H 1 B B—$T_2$ M | 54,000 | 99,000 | .00155 | 18.20 | 31.80 | 1 inch from end of specimen | Accepted. Also 2 and 3. |
| 14309 | 7 H 4 B B—$T_1$ M | 53,000 | 96,000 | .00165 | 20.00 | 33.10 | 1½ inches from end of specimen | Accepted. Also 5 and 6. |
| 14327 | 7 H 7 B B—$T_1$ M | 50,000 | 93,500 | .00155 | 18.50 | 32.15 | ⅞ inch from end of specimen | Accepted. Also 8 and 9. |
| 14328 | 7 H 10 B B—$T_1$ M | 51,000 | 94,000 | .00160 | 18.30 | 36.30 | ⅝ inch from end of specimen | Accepted. |

## *The Midvale Steel Works.—Tensile tests for 7-inch B. L. R. howitzer (steel, siege)*—Continued.

### TABLE XIII.—BREECH MECHANISM—Continued.

| Mid-vale No. | Marks on specimens. | Elastic limit per square inch of original section. | Ultimate strength per square inch of original section. | Elongation per inch under stress at elastic limit. | Ultimate elongation after rupture, per cent of original length. | Reduction in area after rupture, per cent of original section. | Position of rupture. | Remarks relative to acceptance, rejection, retreatment, etc. |
|---|---|---|---|---|---|---|---|---|
|  | *Nuts.* | *Pounds.* | *Pounds.* |  |  |  |  |  |
| 14308 | 7 H 1 N—$L_1$ M | 58,000 | 94,000 | .00155 | 26.50 | 57.06 | 1⅛ inches from end of specimen | Accepted. Also 2 to 10, inclusive. |
|  | *Gas-checks.* |  |  |  |  |  |  |  |
| 14533 | 7 H 1 G C—$T_2$ M | 82,000 | 136,000 | .00220 | 12.60 | 26.46 | ⅜ inch from end of specimen | Accepted. Also 2 to 6, inclusive. |
| 14518 | 7 H 8 G C—$T_1$ M | 76,000 | 127,500 | .00205 | 14.40 | 21.66 | ⅜ inch from end of specimen | Accepted. Also 7 to 12, inclusive. |
| 14534 | 7 H 15 G C—$T_1$ M | 80,000 | 135,650 | .00220 | 6.70 | 6.99 | ⅞ inch from end of specimen | Broke through a small slag spot. A second bar taken. Accepted. Also 13 to 18, inclusive. |
| 14543 | 7 H 15 G C—$T_2$ M | 83.000 | 136,000 | .00220 | 12.80 | 21.66 | ⅝ inch from end of specimen |  |
| 14535 | 7 H 20 G C—$T_1$ M | 80,000 | 137,500 | .00235 | 12.30 | 16.32 | ⅞ inch from end of specimen | Accepted. Also 19. |

## *Tensile tests for 12-inch B. L. rifled mortars (cast-iron body, steel hooped).*

### TABLE XIV.—TRUNNION HOOPS ($B_2$).

[Specimens 4 inches long between shoulders, diameter 0.564 inch, and 0.25 square inch cross section. Contract of December 1, 1890.]

| Mid-vale No. | Marks on specimens. | Elastic limit per square inch of original section. | Ultimate strength per square inch of original section. | Elongation per inch under stress at elastic limit. | Ultimate elongation after rupture, per cent of original length. | Reduction in area after rupture, per cent of original section. | Position of rupture. | Remarks relative to acceptance, rejection, retreatment, etc. |
|---|---|---|---|---|---|---|---|---|
| 14765 | 12 M R 32 T H—$T_1$ O | 60,000 | 112,800 | .00200 | 14.40 | 25.13 | ¾ inch from end of specimen | Accepted. |
| 14802 | 32 T H—$T_2$ M | 56,000 | 110,400 | .00187 | 12.55 | 20.45 | 1½ inches from end of specimen |  |
| 14795 | 32 T H—$T_3$ I | 62,000 | 112,800 | .00190 | 15.30 | 28.76 | 1 inch from end of specimen |  |
| 15302 | 12 M R 33 T H—$T_1$ O | 55,000 | 103,600 | .00170 | 16.20 | 35.78 | 2 inches from end of specimen | Accepted. |
| 15291 | 33 T H—$T_2$ M | 53,000 | 103,200 | .00162 | 15.00 | 30.85 | 1 inch from end of specimen |  |
| 15303 | 33 T H—$T_3$ I | 55,000 | 104,000 | .00175 | 16.30 | 29.66 | 1⅝ inches from end of specimen |  |
| 15410 | 12 M R 34 T H—$T_1$ O | 56,000 | 103,600 | .00177 | 19.40 | 38.86 | 2 inches from end of specimen | Accepted. |
| 15382 | 34 T H—$T_2$ M | 58,000 | 107,200 | .00167 | 14.40 | 29.96 | 1¼ inches from end of specimen |  |
| 15411 | 34 T H—$T_3$ I | 58,000 | 105,600 | .00185 | 16.20 | 36.06 | 1 inch from end of specimen |  |
| 15440 | 12 M R 35 T H—$T_1$ O | 56,000 | 108,000 | .00180 | 15.00 | 30.25 | 1½ inches from end of specimen | Not accepted on these tests. |
| 15414 | 35 T H—$T_2$ M | 57,000 | 108,800 | .00180 | 13.45 | 24.20 | 1⅝ inches from end of specimen |  |
| 15439 | 35 T H—$T_3$ I | 64,000 | 112,600 | .00205 | 9.10 | 9.69 | ¼ inch from end of specimen |  |
| 15553 | 35 T H—$T_4$ O | 55,000 | 100,000 | .00175 | 20.30 | 46.64 | 2 inches from end of specimen | Accepted. |
| 15494 | 35 T H—$T_5$ M | 55,000 | 103,600 | .00167 | 15.00 | 22.84 | 1½ inches from end of specimen |  |
| 15516 | 35 T H—$T_6$ I | 59,000 | 102,800 | .00182 | 17.90 | 44.02 | 1 inch from end of specimen |  |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 15487 | 12 M R 37 T H—$T_1$ O | 56,000 | 109,600 | .00177 | 15.40 | 29.07 | 1⅜ inches from end of specimen | Accepted. |
| 15476 | 37 T H—$T_2$ M | 56,000 | 108,800 | .00180 | 15.00 | 24.82 | 1¾ inches from end of specimen | |
| 15488 | 37 T H—$T_3$ I | 54,000 | 109,200 | .00172 | 14.20 | 30.25 | 2 inches from end of specimen | |
| 15606 | 12 M R 39 T H—$T_1$ O | 52,000 | 103,200 | .00172 | 15.30 | 27.26 | 2 inches from end of specimen | Accepted. |
| 15607 | 39 T H—$T_2$ M | 52,000 | 102,400 | .00167 | 14.80 | 32.82 | 1¼ inches from end of specimen | |
| 15596 | 39 T H—$T_3$ I | 57,000 | 106,400 | .00182 | 15.00 | 32.61 | 1 inch from end of specimen | |
| 15902 | 12 M R 40 T H—$T_1$ O | 57,000 | 102,000 | .00175 | 15.40 | 34.05 | 2⅛ inches from end of specimen | Accepted. |
| 15903 | 40 T H—$T_2$ M | 57,000 | 106,400 | .00167 | 12.60 | 23.89 | 1⅛ inches from end of specimen | |
| 15884 | 40 T H—$T_3$ I | 61,000 | 103,600 | .00182 | 16.50 | 35.78 | 1¼ inches from end of specimen | |
| 15947 | 12 M R 41 T H—$T_1$ O | 55,000 | 98,400 | .00167 | 19.20 | 47.15 | 1⅜ inches from end of specimen | Accepted. |
| 15931 | 41 T H—$T_2$ M | 55,000 | 98,400 | .00175 | 17.20 | 41.61 | 1 inch from end of specimen | |
| 15954 | 41 T H—$T_3$ I | 59,000 | 100,000 | .00185 | 20.60 | 49.71 | 2¼ inches from end of specimen | |
| 15969 | 12 M R 42 T H—$T_1$ O | 54,000 | 96,200 | .00165 | 21.00 | 51.26 | 2 inches from end of specimen | Accepted. |
| 15948 | 42 T H—$T_2$ M | 53,000 | 98,000 | .00155 | 17.20 | 40.52 | 1⅜ inches from end of specimen | |
| 15997 | 42 T H—$T_3$ I | 52,000 | 96,200 | .00157 | 20.40 | 47.40 | 1⅝ inches from end of specimen | |
| 16013 | 12 M R 44 T H $T_1$ O | 56,000 | 104,800 | .00180 | 15.10 | 36.63 | 2 inches from end of specimen | Accepted. |
| 16014 | 44 T H $T_2$ M | 55,000 | 104,800 | .00155 | 14.45 | 26.96 | 1¾ inches from end of specimen | |
| 15984 | 44 T H $T_3$ I | 58,000 | 106,800 | .00170 | 13.50 | 35.49 | ⅝ inch from end of specimen | |
| 16047 | 12 M R 45 T H $T_1$ O | 58,000 | 104,000 | .00187 | 14.90 | 34.92 | 1¼ inches from end of specimen | Accepted. |
| 16011 | 45 T H $T_2$ M | 50,000 | 100,800 | .00160 | 16.70 | 33.48 | 1½ inches from end of specimen | |
| 16048 | 45 T H $T_3$ I | 53,000 | 102,800 | .00175 | 16.80 | 32.90 | 1 inch from end of specimen | |
| 16075 | 12 M R 46 T H $T_1$ O | 54,000 | 96,400 | .00182 | 17.85 | 44.28 | 1 inch from end of specimen | Accepted. |
| 16012 | 46 T H $T_2$ M | 52,000 | 100,000 | .00162 | 17.00 | 36.34 | 2 inches from end of specimen | |
| 16074 | 46 T H T$I_3$ | 58,000 | 101,200 | .00190 | 17.95 | 41.34 | 2 inches from end of specimen | |
| 16290 | 12 M R 43 T H $T_1$ O | 56,000 | 94,800 | .00175 | 12.30 | 20.15 | 1⅝ inches from end of specimen | Accepted. |
| 16173 | 43 T H $T_3$ I | 56,000 | 98,400 | .00187 | 19.10 | 52.43 | 1 inch from end of specimen | |
| 16191 | 43 T H $T_4$ M | 54,000 | 99,200 | .00160 | 19.60 | 41.61 | 1 inch from end of specimen | |
| 16409 | 12 M R 47 T H $T_1$ O | 56,000 | 107,120 | .00155 | 7.50 | 10.70 | ½ inch from end of specimen | Not accepted on these tests. |
| 16401 | 47 T H $T_2$ M | 52,000 | 104,800 | .00155 | 12.75 | 32.32 | ¾ inch from end of specimen | |
| 16410 | 47 T H $T_3$ I | 60,000 | 112,400 | .00200 | 13.85 | 31.43 | ⅝ inch from end of specimen | |
| 16588 | 12 M R 47 T H $T_4$ O | 55,000 | 101,600 | .00175 | 13.05 | 26.66 | 1¾ inches from end of specimen | Accepted. |
| 16573 | 47 T H $T_5$ M | 50,000 | 101,200 | .00165 | 17.40 | 28.47 | 1⅜ inches from end of specimen | |
| 16588 | 47 T H $T_6$ I | 54,000 | 103,200 | .00175 | 16.70 | 33.19 | 2 inches from end of specimen | |
| 16457 | 12 M R 48 T H $T_1$ O | 54,000 | 106,400 | .00170 | 16.55 | 32.02 | 2 inches from end of specimen | Accepted. |
| 16425 | 48 T H $T_2$ M | 50,000 | 102,800 | .00167 | 13.80 | 26.05 | 1½ inches from end of specimen | |
| 16458 | 48 T H $T_3$ I | 55,000 | 109,600 | .00182 | 15.75 | 29.07 | 1⅜ inches from end of specimen | |
| 16547 | 12 M R 49 T H $T_1$ O | 57,000 | 105,200 | .00190 | 15.90 | 34.05 | 2⅛ inches from end of specimen | Accepted. |
| 16531 | 49 T H $T_4$ M | 51,000 | 101,600 | .00157 | 17.20 | 29.66 | 2⅜ inches from end of specimen | |
| 16548 | 49 T H $T_3$ I | 56,000 | 106,000 | .00165 | 15.50 | 31.43 | 1⅛ inches from end of specimen | |
| 16460 | 12 M R 50 T H $T_1$ O | 56,000 | 105,200 | .00177 | 15.80 | 28.17 | 2⅜ inches from end of specimen | Accepted. |
| 16426 | 50 T H $T_2$ M | 55,000 | 102,800 | .00152 | 18.50 | 37.75 | 2 inches from end of specimen | |
| 16461 | 50 T H $T_3$ I | 59,000 | 103,600 | .00207 | 17.55 | 38.58 | 1⅜ inches from end of specimen | |
| 16606 | 12 M R 51 T H $T_1$ O | 55,000 | 98,400 | .00175 | 18.80 | 40.25 | 1¼ inches from end of specimen | Accepted. |
| 16589 | 51 T H $T_2$ M | 56,000 | 102,800 | .00175 | 12.60 | 19.83 | 1¼ inches from end of specimen | |
| 16607 | 51 T H $T_3$ I | 54,000 | 100,000 | .00170 | 18.50 | 38.30 | 1¾ inches from end of specimen | |
| 16928 | 12 M R 52 T H $T_1$ O | 52,000 | 100,000 | .00172 | 17.30 | 34.64 | 2½ inches from end of specimen | Accepted. |
| 16896 | 52 T H $T_3$ M | 54,000 | 102,800 | .00160 | 16.30 | 32.02 | 1⅝ inches from end of specimen | |
| 19929 | 52 T H $T_4$ I | 58,000 | 104,400 | .00155 | 17.00 | 42.15 | 1¾ inches from end of specimen | |
| 16927 | 12 M R 53 T H $T_1$ O | 53,000 | 102,500 | .00165 | 16.25 | 34.92 | 1⅛ inches from end of specimen | Accepted. |
| 16897 | 53 T H $T_3$ M | 58,000 | 102,400 | .00165 | 17.00 | 36.34 | 1⅝ inches from end of specimen | |
| 16923 | 53 T H $T_4$ I | 60,000 | 105,600 | .00185 | 16.30 | 39.14 | 1¾ inches from end of specimen | |

*Tensile tests for 12-inch B. L. rifled mortars (cast-iron body, steel hooped)*—Continued.

TABLE XIV.—TRUNNION HOOPS ($B_2$)—Continued.

| Midvale No. | Marks on specimens. | Elastic limit per square inch of original section. | Ultimate strength per square inch of original section. | Elongation per inch under stress at elastic limit. | Ultimate elongation after rupture, per cent of original length. | Reduction in area after rupture, per cent of original section. | Position of rupture. | Remarks relative to acceptance, rejection, retreatment, etc. |
|---|---|---|---|---|---|---|---|---|
| | | *Pounds.* | *Pounds.* | | | | | |
| 17027 | 12 M R 54 T H $T_1$ O | 52,000 | 98,800 | .00175 | 17.00 | 34.64 | 2 inches from end of specimen | Accepted. |
| 17006 | 54 T H $T_2$ M | 54,000 | 98,000 | .00162 | 19.40 | 45.86 | 2 inches from end of specimen | |
| 17033 | 54 T H $T_3$ I | 55,000 | 99,200 | .00172 | 18.80 | 47.15 | 1⅛ inches from end of specimen | |
| 17035 | 12 M R 55 T H $T_1$ O | 56,000 | 98,000 | .00172 | 17.10 | 46.64 | 1 inch from end of specimen | Accepted. |
| 17020 | 55 T H $T_2$ M | 52,000 | 98,800 | .00165 | 19.10 | 36.91 | 1¾ inches from end of specimen | |
| 17034 | 55 T H $T_3$ I | 59,000 | 99,000 | .00172 | 19.80 | 52.19 | 1⅛ inches from end of specimen | |
| 17045 | 12 M R 56 T H $T_1$ O | 51,000 | 94,800 | .00150 | 20.30 | 48.44 | 1⅜ inches from end of specimen | Accepted. |
| 17037 | 56 T H $T_2$ M | 51,000 | 95,600 | .00160 | 18.50 | 35.21 | ⅞ inch from end of specimen | |
| 17044 | 56 T H $T_3$ I | 52,000 | 94,880 | .00155 | 21.65 | 52.19 | 1⅛ inches from end of specimen | |
| 17056 | 12 M R 57 T H $T_1$ O | 50,000 | 92,400 | .00160 | 22.00 | 48.70 | 1¾ inches from end of specimen | Accepted. |
| 17043 | 57 T H $T_2$ M | 51,000 | 94,800 | .00162 | 18.30 | 32.02 | 1⅝ inches from end of specimen | |
| 17057 | 57 T H $T_3$ I | 55,000 | 94,800 | .00180 | 20.50 | 53.64 | 2 inches from end of specimen | |

TABLE XV.—HOOPS $A_3$.

[Specimens 3 inches long between shoulders, diameter 0.564 inch, and 0.25 square inch cross section. Contract of December 1, 1890.]

| Midvale No. | Marks on specimens. | Elastic limit per square inch of original section. | Ultimate strength per square inch of original section. | Elongation per inch under stress at elastic limit. | Ultimate elongation after rupture, per cent of original length. | Reduction in area after rupture, per cent of original section. | Position of rupture. | Remarks relative to acceptance, rejection, retreatment, etc. |
|---|---|---|---|---|---|---|---|---|
| 14240 | 12 M R 31 $A_3$—$T_1$ O | 59,000 | 96,000 | .00182 | 17.20 | 45.84 | 1¾ inches from end of specimen | Accepted. Also 32 $A_1$. |
| 14233 | 31 $A_3$—$T_2$ M | 58,000 | 96,400 | .00182 | 19.10 | 51.94 | 2¼ inches from end of specimen | |
| 14239 | 31 $A_3$—$T_4$ I | 55,000 | 96,000 | .00150 | 18.60 | 51.45 | 2 inches from end of specimen | |
| 14377 | 12 M R 33 $A_3$—$T_1$ O | 54,000 | 100,800 | .00172 | 13.18 | 17.91 | 1¼ inches from end of specimen | Accepted. Also 33 $A_1$. |
| 14348 | 33 $A_3$—$T_2$ M | 58,000 | 106,000 | .00182 | 14.47 | 30.55 | 1½ inches from end of specimen | |
| 14378 | 33 $A_3$—$T_3$ I | 59,000 | 107,600 | .00190 | 13.50 | 33.76 | ⅝ inch from end of specimen | |
| 14426 | 12 M R 34 $A_3$—$T_1$ O | 60,000 | 105,600 | .00202 | 15.70 | 39.41 | 1⅛ inches from end of specimen | Accepted. |
| 14374 | 34 $A_3$—$T_2$ M | 56,000 | 102,000 | .00175 | 17.50 | 34.64 | 2 inches from end of specimen | |
| 14427 | 34 $A_3$—$T_3$ I | 56,000 | 99,600 | .00180 | 16.00 | 44.54 | 1 inch from end of specimen | |
| 14451 | 12 M R 36 $A_3$—$T_1$ O | 57,000 | 100,000 | .00177 | 17.60 | 39.69 | 2 inches from end of specimen | Accepted. Also 34 $A_1$. |
| 14401 | 36 $A_3$—$T_2$ M | 58,000 | 100,000 | .00180 | 18.30 | 44.28 | 1¾ inches from end of specimen | |
| 14452 | 36 $A_3$—$T_3$ I | 55,000 | 96,000 | .00180 | 20.50 | 51.45 | 2¼ inches from end of specimen | |
| 14428 | 12 M R 35 $A_3$—$T_1$ O | 61,000 | 109,200 | .00200 | 13.50 | 22.84 | 2⅛ inches from end of specimen | Accepted. Also 35 $A_1$. |
| 14379 | 35 $A_3$—$T_2$ M | 54,000 | 104,400 | .00170 | 13.10 | 29.66 | 1 inch from end of specimen | |
| 14427 | 35 $A_3$—$T_3$ I | 61,000 | 108,400 | .00197 | 14.60 | 34.64 | 2 inches from end of specimen | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 14456 | 12 M R 37 $A_5$—$T_1$ O | 63,000 | 105,600 | .00197 | 16.20 | 44.02 | 1 inch from end of specimen | Accepted. Also 36 $A_1$. |
| 14484 | 37 $A_5$—$T_2$ M | 62,000 | 106,600 | .00195 | 15.20 | 40.52 | 1¼ inches from end of specimen | |
| 14466 | 37 $A_5$—$T_3$ I | 60,000 | 100,400 | .00180 | 19.30 | 49.46 | 1 inch from end of specimen | |
| 14497 | 12 M R 38 $A_5$—$T_1$ O | 62,000 | 109,200 | .00205 | 15.90 | 38.03 | 1½ inches from end of specimen | Accepted. Also 37 $A_1$. |
| 14455 | 38 $A_5$—$T_2$ M | 58,000 | 107,600 | .00177 | 16.70 | 36.06 | 1½ inches from end of specimen | |
| 14498 | 38 $A_5$—$T_3$ I | 63,000 | 106,400 | .00205 | 17.50 | 43.75 | 1 inch from end of specimen | |
| 15063 | 12 M R 40 $A_5$—$T_1$ O | 61,000 | 110,800 | .00207 | 13.50 | 32.82 | 2 inches from end of specimen | Accepted. Also 38 $A_1$. No. 40 $A_5$ was changed after test to No. 47 $A_4$. |
| 15029 | 40 $A_5$—$T_2$ M | 62,000 | 113,600 | .00200 | 13.10 | 30.55 | 1½ inches from end of specimen | |
| 15066 | 40 $A_5$—$T_3$ I | 66,000 | 115,600 | .00205 | 14.20 | 31.43 | 1 inch from end of specimen | |
| 15081 | 12 M R 41 $A_5$—$T_1$ O | 58,000 | 108,000 | .00192 | 14.35 | 29.07 | ⅝ inch from end of specimen | Accepted. Also 39 $A_1$. |
| 15068 | 41 $A_5$—$T_2$ M | 57,000 | 106,000 | .00177 | 16.70 | 34.64 | 1¾ inches from end of specimen | |
| 15090 | 41 $A_5$—$T_3$ I | 62,000 | 110,400 | .00200 | 17.00 | 35.78 | 2 inches from end of specimen | |
| 15100 | 12 M R 42 $A_5$—$T_1$ O | 60,000 | 108,000 | .00182 | 13.50 | 30.85 | 1⅛ inches from end of specimen | Accepted. Also 40 $A_1$. |
| 15079 | 42 $A_5$—$T_2$ M | 61,000 | 107,200 | .00200 | 14.10 | 30.25 | 2½ inches from end of specimen | |
| 15099 | 42 $A_5$—$T_3$ I | 58,000 | 103,600 | .00187 | 14.60 | 40.52 | 2 inches from end of specimen | |
| 15220 | 12 M R 43 $A_5$—$T_1$ O | 61,000 | 109,200 | .00200 | 15.50 | 37.47 | 1¼ inches from end of specimen | Accepted. Also 44 $A_1$. |
| 15189 | 43 $A_5$—$T_2$ M | 58,000 | 104,800 | .00177 | 15.60 | 35.48 | 1½ inches from end of specimen | |
| 15244 | 43 $A_5$—$T_4$ I | 59,000 | 102,800 | .00180 | 16.80 | 42.95 | 1⅝ inches from end of specimen | |

[Specimens 4 inches long between shoulders, diameter 0.564 inch, and 0.25 square inch cross section.]

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 15138 | 12 M R 44 $A_3$ | $T_1$ O | 58,000 | 105,600 | .00177 | 17.60 | 40.52 | 1¾ inches from end of specimen | Accepted. Also No. 44 $A_1$. |
| 15106 | 44 $A_3$ | $T_2$ M | 59,000 | 108,000 | .00197 | 17.20 | 40.79 | 2 inches from end of specimen | |
| 15137 | 44 $A_3$ | $T_3$ I | 64,000 | 109,200 | .00205 | 16.30 | 45.60 | 1 inch from end of specimen | |
| 15150 | 12 M R 45 $A_3$ | $T_1$ O | 63,000 | 108,800 | .00200 | 15.00 | 30.55 | 2 inches from end of specimen | Accepted. Also No. 42 $A_1$. |
| 15107 | 45 $A_3$ | $T_2$ M | 61,000 | 107,600 | .00205 | 15.20 | 28.77 | 2 inches from end of specimen | |
| 15149 | 45 $A_3$ | $T_3$ I | 62,000 | 108,800 | .00192 | 13.30 | 29.07 | ½ inch from end of specimen | |
| 15173 | 12 M R 46 $A_3$ | $T_1$ O | 57,000 | 103,600 | .00185 | 18.80 | 45.34 | 2 inches from end of specimen | Accepted. Also No. 43 $A_1$. |
| 15134 | 46 $A_3$ | $T_2$ M | 57,000 | 102,400 | .00187 | 18.00 | 42.15 | 2 inches from end of specimen | |
| 15161 | 46 $A_3$ | $T_3$ I | 61,000 | 105,200 | .00205 | 17.60 | 43.75 | 1½ inches from end of specimen | |
| 16281 | 12 M R 47 $A_3$ | $T_1$ O | 61,000 | 105,600 | .00185 | 18.50 | 39.14 | 1½ inches from end of specimen | Accepted. Also No. 49 $A_1$. |
| 16282 | 47 $A_3$ | $T_3$ I | 62,000 | 101,600 | .00187 | 16.50 | 48.18 | 1¾ inches from end of specimen | |
| 16256 | 47 $A_3$ | $T_4$ M | 57,000 | 100,800 | .00175 | 16.45 | 32.61 | 1⅝ inches from end of specimen | |
| 16258 | 12 M R 39 $A_3$ | $T_1$ O | 58,000 | 110,800 | .00177 | 14.20 | 27.87 | 1½ inches from end of specimen | Accepted. Also No. 48 $A_1$. |
| 16172 | 39 $A_3$ | $T_2$ M | 60,000 | 112,000 | .00185 | 14.50 | 28.47 | 1⅝ inches from end of specimen | |
| 16262 | 39 $A_3$ | $T_3$ I | 67,000 | 113,600 | .00210 | 13.25 | 34.92 | 1½ inches from end of specimen | |
| 16230 | 12 M R 40 $A_3$ | $T_1$ O | 56,000 | 106,800 | .00180 | 15.50 | 28.77 | 1½ inches from end of specimen | Accepted. Also No. 46 $A_1$. |
| 16154 | 40 $A_3$ | $T_2$ M | 54,000 | 105,200 | .00160 | 15.80 | 30.53 | 1¾ inches from end of specimen | |
| 16220 | 40 $A_3$ | $T_3$ I | 59,000 | 108,000 | .00175 | 15.80 | 29.66 | 1⅝ inches from end of specimen | |
| 16281 | 12 M R 47 $A_3$ | $T_1$ O | 61,000 | 105,600 | .00185 | 18.50 | 39.14 | 1½ inches from end of specimen | Accepted. Also No. 49 $A_1$. |
| 16283 | 47 $A_3$ | $T_3$ I | 62,000 | 101,600 | .00187 | 16.50 | 48.18 | 1¾ inches from end of specimen | |
| 16256 | 47 $A_3$ | $T_4$ M | 57,000 | 100,800 | .00175 | 16.45 | 32.61 | 1⅝ inches from end of specimen | |
| 16229 | 12 M R 48 $A_3$ | $T_1$ O | 60,000 | 113,200 | .00187 | 14.80 | 28.17 | 2 inches from end of specimen | Accepted. Also No. 47 $A_1$. |
| 16153 | 48 $A_3$ | $T_2$ M | 57,000 | 110,800 | .00187 | 14.90 | 25.43 | 2½ inches from end of specimen | |
| 16228 | 48 $A_3$ | $T_3$ I | 58,000 | 110,000 | .00180 | 14.10 | 32.90 | 1 inch from end of specimen | |
| 16209 | 12 M R 49 $A_3$ | $T_1$ O | 57,000 | 109,200 | .00182 | 13.60 | 27.87 | 1¾ inches from end of specimen | Accepted. Also No. 45 $A_1$. |
| 16174 | 49 $A_3$ | $T_2$ M | 59,000 | 110,400 | .00187 | 14.20 | 26.66 | 1¼ inches from end of specimen | |
| 16208 | 49 $A_3$ | $T_3$ I | 62,000 | 108,800 | .00180 | 13.70 | 31.43 | 1½ inches from end of specimen | |

### *Tensile tests for 12-inch B. L. rifled mortars (cast-iron body, steel hooped)*—Continued.

TABLE XV.—HOOPS $A_3$—Continued.

| Mid-vale No. | Marks on specimens. | Elastic limit per square inch of original section. | Ultimate strength per square inch of original section. | Elongation per inch under stress at elastic limit. | Ultimate elongation after rupture, per cent of original length. | Reduction in area after rupture, per cent of original section. | Position of rupture. | Remarks relative to acceptance, rejection, retreatment, etc. |
|---|---|---|---|---|---|---|---|---|
| | | *Pounds.* | *Pounds.* | | | | | |
| 16335 | 12 M R 50 $A_3$ $T_1$ O | 59,000 | 111,200 | .00182 | 15.80 | 28.47 | 1⅞ inches from end of specimen | Accepted. Also No. 51 $A_1$. |
| 16297 | 50 $A_3$ $T_2$ M | 59,000 | 109,600 | .00177 | 14.70 | 30.85 | 2 inches from end of specimen | |
| 16336 | 50 $A_3$ $T_3$ I | 56,000 | 103,600 | .00160 | 16.00 | 34.05 | 1⅝ inches from end of specimen | |
| 16394 | 12 M R 53 $A_3$ $T_1$ O | 59,000 | 102,800 | .00175 | 18.00 | 39.41 | 2¼ inches from end of specimen | Accepted. Also No. 48 $A_3$. |
| 16386 | 53 $A_3$ $T_2$ M | 53,000 | 97,600 | .00162 | 17.90 | 40.25 | 1¾ inches from end of specimen | |
| 16399 | 53 $A_3$ $T_3$ I | 54,000 | 96,800 | .00160 | 18.80 | 46.64 | 1¾ inches from end of specimen | |
| 16309 | 12 M R 52 $A_3$ $T_1$ O | 54,000 | 97,200 | .00170 | 14.60 | 22.96 | 1⅜ inches from end of specimen | Accepted. Also No. 50 $A_1$. |
| 16284 | 52 $A_3$ $T_2$ M | 51,000 | 100,400 | .00152 | 17.30 | 43.49 | 1¾ inches from end of specimen | |
| 16311 | 52 $A_3$ $T_3$ I | 56,000 | 98,800 | .00180 | 18.00 | 42.95 | 1¾ inches from end of specimen | |
| 16400 | 12 M R 54 $A_3$ $T_1$ O | 59.000 | 102,400 | .00192 | 14.80 | 33.19 | ⅞ inch from end of specimen | Accepted. Also No. 52 $A_1$. |
| 16384 | 54 $A_3$ $T_2$ M | 58,000 | 101,600 | .00165 | 15.30 | 33.19 | 2 inches from end of specimen | |
| 16404 | 54 $A_3$ $T_3$ I | 56,000 | 98,800 | .00160 | 17.80 | 49.20 | 1 inch from end of specimen | |
| 16452 | 12 M R 55 $A_3$ $T_1$ O | 55,000 | 100,000 | .00160 | 18.10 | 41.61 | 2 inches from end of specimen | Accepted. Also No. 53 $A_1$. |
| 16406 | 55 $A_3$ $T_2$ M | 56,000 | 98,400 | .00185 | 15.50 | 25.13 | 1⅜ inches from end of specimen | |
| 16451 | 55 $A_3$ $T_3$ I | 55,000 | 97,600 | .00150 | 18.00 | 47.66 | 1¼ inches from end of specimen | |
| 16500 | 12 M R 57 $A_3$ $T_1$ O | 60,000 | 103,600 | .00182 | 16.35 | 39.69 | 1 inch from end of specimen | Accepted. Also No. 54 $A_1$. |
| 16433 | 57 $A_3$ $T_2$ M | 57,000 | 101,600 | .00187 | 17.90 | 34.64 | 1¼ inches from end of specimen | |
| 16503 | 57 $A_3$ $T_3$ I | 60,000 | 106,000 | .00185 | 17.80 | 40.25 | 1 inch from end of specimen | |
| 16571 | 12 M R 58 $A_3$ $T_1$ O | 57,000 | 100,800 | .00187 | 15.10 | 26.85 | 1¼ inches from end of specimen | Accepted. Also No. 55 $A_1$ |
| 16516 | 58 $A_3$ $T_2$ M | 57,000 | 102,800 | .00182 | 17.00 | 40.79 | 2 inches from end of specimen | |
| 16572 | 58 $A_3$ $T_3$ I | 68,000 | 105,200 | .00200 | 14.20 | 43.22 | ⅞ inch from end of specimen | |
| 16683 | 12 M R 61 $A_3$ $T_2$ M | 57,000 | 102,800 | .00177 | 18.65 | 40.52 | 1⅞ inches from end of specimen | Accepted. Also No. 56 $A_1$. |
| 16711 | 61 $A_3$ $T_1$ O | 62,000 | 102,800 | .00196 | 18.20 | 44.54 | 2 inches from end of specimen | |
| 16722 | 61 $A_3$ $T_3$ I | 59,000 | 100,800 | .00175 | 19.40 | 47.66 | 1⅜ inches from end of specimen | |
| 16812 | 12 M R 62 $A_3$ $T_1$ O | 62,000 | 108,800 | .00202 | 16.50 | 31.73 | 1¾ inches from end of specimen | Accepted. Also No. 58 $A_1$. |
| 16710 | 62 $A_3$ $T_2$ M | 57,000 | 105,600 | .00175 | 16.35 | 35.21 | 1⅜ inches from end of specimen | |
| 16813 | 62 $A_3$ $T_3$ I | 64,000 | 108,400 | .00200 | 14.50 | 39.41 | 1¼ inches from end of specimen | |
| 16726 | 12 M R 63 $A_3$ $T_1$ O | 54,000 | 102,000 | .00177 | 17.10 | 39.14 | 2¼ inches from end of specimen | Accepted. Also No. 57 $A_1$. |
| 16707 | 63 $A_3$ $T_2$ M | 53,000 | 98,400 | .00155 | 16.40 | 38.58 | 1¼ inches from end of specimen | |
| 16728 | 03 $A_3$ $T_3$ I | 55,000 | 97,600 | .00175 | 16.65 | 44.81 | 1⅜ inches from end of specimen | |
| 16617 | 12 M R 59 $A_3$ $T_1$ O | 56,000 | 106,800 | .00182 | 15.20 | 33.48 | 2 inches from end of specimen | Accepted. Also No. 52 $B_3$. |
| 16585 | 59 $A_3$ $T_2$ M | 55,000 | 104,400 | .00160 | 14.30 | 32.61 | 1⅜ inches from end of specimen | |
| 16618 | 59 $A_3$ $T_3$ I | 61,000 | 110,400 | .00182 | 14.40 | 33.48 | 2 inches from end of specimen | |
| 17007 | 12 M R 64 $A_3$ $T_1$ O | 57,000 | 98,800 | .00177 | 18.60 | 44.54 | 1¼ inches from end of specimen | Accepted. Also No. 59 $A_1$. |
| 16982 | 64 $A_3$ $T_2$ M | 57,000 | 100,000 | .00182 | 19.30 | 42.42 | 2¼ inches from end of specimen | |
| 17008 | 64 $A_3$ $T_4$ I | 56,000 | 98,000 | .00177 | 16.30 | 39.41 | 1⅜ inches from end of specimen | |

TABLE XVI.—HOOPS $A_4$.

[Specimens 3 inches long between shoulders, diameter 0.564 inch, and 0.25 square inch cross section.]

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 14148 | 12 M R 31 $A_4$—$T_1$ O | 56,000 | 97,800 | .00175 | 17.78 | 42.15 | 2 inches from end of specimen | Accepted. |
| 14112 | 31 $A_4$—$T_2$ M | 53,000 | 96,800 | .00177 | 16.42 | 39.14 | 1½ inches from end of specimen | |
| 14161 | 31 $A_4$—$T_3$ I | 56,000 | 94,000 | .00175 | 18.70 | 56.03 | 2 inches from end of specimen | |
| 14225 | 12 M R 33 $A_4$—$T_1$ O | 57,000 | 104,000 | .00187 | 14.60 | 26.35 | 1¾ inches from end of specimen | Accepted. Also No. 31 $A_3$. |
| 14207 | 33 $A_4$—$T_2$ M | 56,000 | 102,000 | .00182 | 13.10 | 21.72 | ⅝ inch from end of specimen | |
| 14218 | 33 $A_4$—$T_3$ I | 57,000 | 100,000 | .00177 | 15.60 | 41.88 | 2 inches from end of specimen | |
| 14286 | 12 M R 35 $A_4$—$T_1$ O | 55,000 | 96,000 | .00170 | 17.20 | 31.14 | 1¾ inches from end of specimen | Accepted. Also No. 32 $A_3$. |
| 14222 | 35 $A_4$—$T_2$ M | 52,000 | 94,800 | .00165 | 18.20 | 39.41 | 2 inches from end of specimen | |
| 14237 | 35 $A_4$—$T_3$ I | 56,000 | 96,000 | .00185 | 17.50 | 48.70 | 1 inch from end of specimen | |
| 14402 | 12 M R 37 $A_4$—$T_1$ O | 57,000 | 108,800 | .00180 | 16.90 | 29.07 | 2½ inches from end of specimen | Accepted. Also No. 33 $A_3$. |
| 14372 | 37 $A_4$—$T_2$ M | 58,000 | 108,400 | .00190 | 15.80 | 26.96 | 1 inch from end of specimen | |
| 14408 | 37 $A_4$—$T_3$ I | 60,000 | 109,600 | .00180 | 15.70 | 28.47 | 2½ inches from end of specimen | |
| 14449 | 12 M R 38 $A_4$—$T_1$ O | 62,000 | 105,000 | .00200 | 17.30 | 39.14 | 1¾ inches from end of specimen | Accepted. Also No. 35 $A_3$. |
| 14400 | 38 $A_4$—$T_2$ M | 60,000 | 105,600 | .00190 | 16.20 | 35.49 | 1¾ inches from end of specimen | |
| 14459 | 38 $A_4$—$T_3$ I | 63,000 | 106,000 | .00190 | 18.10 | 41.07 | 1¾ inches from end of specimen | |
| 14430 | 12 M R 39 $A_4$—$T_1$ O | 59,000 | 103,200 | .00200 | 16.90 | 41.34 | ¾ inch from end of specimen | Accepted. Also No. 34 $A_3$. |
| 14398 | 39 $A_4$—$T_2$ M | 57,000 | 102,000 | .00177 | 13.90 | 24.82 | 1⅝ inches from end of specimen | |
| 14431 | 39 $A_4$—$T_3$ I | 55,000 | 100,800 | .00180 | 14.20 | 40.25 | 2 inches from end of specimen | |
| 14457 | 12 M R 40 $A_4$—$T_1$ O | 54,000 | 100,000 | .00175 | 16.00 | 34.05 | 1½ inches from end of specimen | Accepted. Also No. 36 $A_3$. |
| 14435 | 40 $A_4$—$T_2$ M | 54,000 | 98,800 | .00177 | 16.70 | 35.21 | 1⅝ inches from end of specimen | |
| 14467 | 40 $A_4$—$T_3$ I | 57,000 | 98,800 | .00187 | 16.20 | 44.81 | ⅝ inch from end of specimen | |
| 15139 | 12 M R 32 $A_4$—$T_1$ O | 62,000 | 108,000 | .00202 | 17.30 | 45.07 | 2 inches from end of specimen | Accepted. Also No. 39 $A_3$. |
| 15125 | 32 $A_4$—$T_3$ M | 58,000 | 99,200 | .00190 | 19.90 | 49.71 | 2 inches from end of specimen | |
| 15148 | 32 $A_4$—$T_4$ I | 60,000 | 101,600 | .00180 | 19.50 | 53.64 | 1⅝ inches from end of specimen | |
| 15193 | 12 M R 34 $A_4$—$T_1$ O | 54,000 | 103,200 | .00180 | 15.60 | 32.32 | 2 inches from end of specimen | Accepted. Also No. 41 $A_3$. |
| 15175 | 34 $A_4$—$T_3$ M | 54,000 | 101,600 | .00190 | 16.50 | 34.64 | ¾ inch from end of specimen | |
| 15192 | 34 $A_4$—$T_4$ I | 53,000 | 99,600 | .00175 | 15.80 | 37.47 | 1⅝ inches from end of specimen | |
| 15172 | 12 M R 36 $A_4$—$T_1$ O | 69,000 | 115,600 | .00200 | 15.90 | 38.58 | 1¼ inches from end of specimen | Accepted. Also No. 40 $A_3$. |
| 15126 | 36 $A_4$—$T_3$ M | 69,000 | 115,600 | .00230 | 16.25 | 39.41 | 1⅝ inches from end of specimen | |
| 15171 | 36 $A_4$—$T_4$ I | 66,000 | 111,200 | .00205 | 14.20 | 39.69 | 1¼ inches from end of specimen | |
| 15018 | 12 M R 41 $A_4$—$T_1$ M | 59,000 | 102,800 | .00195 | 16.30 | 41.61 | 2 inches from end of specimen | Accepted. Also No. 37 $B_3$. No outside bar was taken from this hoop. |
| 14975 | 41 $A_4$—$T_2$ M | 58,000 | 102,000 | .00180 | 17.00 | 41.61 | 1¼ inches from end of specimen | |
| 15023 | 41 $A_4$—$T_3$ I | 60,000 | 101,200 | .00195 | 14.80 | 32.90 | 2 inches from end of specimen | |

[Specimens 4 inches long between shoulders, diameter 0.564 inch, and 0.25 square inch cross section.]

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 15245 | 12 M R 42 $A_4$ $T_1$ O | 63,000 | 103,200 | .00200 | 16.80 | 42.15 | 2 inches from end of specimen | Accepted. Also No. 43 $A_3$. |
| 15246 | 42 $A_4$ $T_3$ M | 62,000 | 105,600 | .00200 | 16.10 | 39.14 | 1½ inches from end of specimen | |
| 15199 | 42 $A_4$ $T_4$ I | 63,000 | 106,800 | .00197 | 15.40 | 42.42 | 1¾ inches from end of specimen | |
| 15091 | 12 M R 43 $A_4$ $T_1$ O | 61,000 | 109,200 | .00205 | 15.60 | 35.78 | 1½ inches from end of specimen | Accepted. |
| 15067 | 43 $A_4$ $T_3$ M | 59,000 | 109,600 | .00197 | 14.50 | 26.96 | 2 inches from end of specimen | |
| 15092 | 43 $A_4$ $T_3$ I | 61,000 | 108,400 | .00195 | 16.50 | 36.63 | 2 inches from end of specimen | |

*Tensile tests for 12-inch B. L. rifled mortars (cast-iron body, steel hooped)*—Continued.

TABLE XVI.—HOOPS $A_4$—Continued.

| Mid-vale No. | Marks on specimens. | Elastic limit per square inch of original section. | Ultimate strength per square inch of original section. | Elongation per inch under stress at elastic limit. | Ultimate elongation after rupture, per cent of original length. | Reduction in area after rupture, per cent of original section. | Position of rupture. | Remarks relative to acceptance, rejection, retreatment, etc. |
|---|---|---|---|---|---|---|---|---|
| | | *Pounds.* | *Pounds.* | | | | | |
| 15094 | 12 M R 44 $A_4$ $T_1$ O | 61,000 | 107,600 | .00200 | 18.10 | 42.42 | 2⅜ inches from end of specimen | Accepted. Also No. 37 $A_3$. |
| 15071 | 44 $A_4$ $T_2$ M | 61,000 | 107,200 | .00200 | 18.50 | 44.02 | 2 inches from end of specimen | |
| 15102 | 44 $A_4$ $T_3$ I | 63,000 | 109,600 | .00205 | 15.60 | 40.79 | 1½ inches from end of specimen | |
| 15136 | 12 M R 45 $A_4$ $T_1$ O | 62,000 | 110,800 | .00205 | 13.60 | 29.37 | 1⅝ inches from end of specimen | Accepted. Also No. 38 $A_3$. |
| 15103 | 45 $A_4$ $T_2$ M | 62,000 | 111,200 | .00205 | 14.90 | 36.06 | 1¼ inches from end of specimen | |
| 15128 | 45 $A_4$ $T_3$ I | 63,000 | 108,000 | .00202 | 14.80 | 39.14 | 1¾ inches from end of specimen | |
| 15202 | 12 M R 46 $A_4$ $T_1$ O | 59,000 | 108,000 | .00192 | 15.40 | 39.41 | 1 inch from end of specimen | Accepted. Also No. 42 $A_3$. |
| 15176 | 46 $A_4$ $T_2$ M | 58,000 | 107,600 | .00182 | 16.30 | 36.34 | 2 inches from end of specimen | |
| 15203 | 46 $A_4$ $T_3$ I | 63,000 | 110,000 | .00200 | 16.00 | 39.69 | 1¾ inches from end of specimen | |
| 16097 | 12 M R 48 $A_4$ $T_1$ O | 68,000 | 118,000 | .00212 | 15.75 | 32.90 | 2 inches from end of specimen | Accepted. Also No. 44 $A_3$. |
| 16073 | 48 $A_4$ $T_2$ M | 61,000 | 110,800 | .00192 | 14.10 | 32.61 | 2 inches from end of specimen | |
| 16098 | 48 $A_4$ $T_3$ I | 62,000 | 111,200 | .00195 | 14.10 | 33.48 | 2 inches from end of specimen | |
| 16148 | 12 M R 49 $A_4$ $T_1$ O | 59,000 | 108,400 | .00175 | 14.20 | 32.02 | 2 inches from end of specimen | Accepted. Also No. 46 $A_3$. |
| 16105 | 49 $A_4$ $T_2$ M | 55,000 | 104,800 | .00170 | 16.50 | 33.76 | 2¼ inches from end of specimen | |
| 16142 | 49 $A_4$ $T_3$ I | 56,000 | 100,000 | .00185 | 17.90 | 44.02 | 2 inches from end of specimen | |
| 16149 | 12 M R 50 $A_4$ $T_1$ O | 56,000 | 105,200 | .00182 | 12.90 | 15.32 | 2 inches from end of specimen | Accepted. Also No. 47 $A_3$. |
| 16099 | 50 $A_4$ $T_2$ M | 52,000 | 98,000 | .00165 | 17.10 | 31.76 | 1¾ inches from end of specimen | |
| 16153 | 50 $A_4$ $T_3$ I | 53,000 | 97,200 | .00172 | 19.80 | 44.54 | 2 inches from end of specimen | |
| 16143 | 12 M R 51 $A_4$ $T_1$ O | 57,000 | 104,800 | .00180 | 17.60 | 34.05 | 1½ inches from end of specimen | Accepted. Also No. 45 $A_3$. This No. was changed to No. 51 $A_3$. |
| 16103 | 51 $A_4$ $T_2$ M | 56,000 | 104,400 | .00180 | 15.90 | 30.85 | 1¾ inches from end of specimen | |
| 16147 | 51 $A_4$ $T_3$ I | 57,000 | 102,800 | .00182 | 15.50 | 35.78 | 2⅛ inches from end of specimen | |
| 16329 | 12 M R 52 $A_4$ $T_1$ O | 60,000 | 109,200 | .00180 | 15.50 | 33.19 | 2 inches from end of specimen | Accepted. Also No. 56 $A_3$. |
| 16257 | 52 $A_4$ $T_2$ M | 59,000 | 108,400 | .00187 | 15.70 | 32.61 | 2 inches from end of specimen | |
| 16334 | 52 $A_4$ $T_3$ I | 64,000 | 110,000 | .00190 | 15.60 | 37.47 | ¾ inch from end of specimen | |
| 16307 | 12 M R 53 $A_4$ $T_1$ O | 56,000 | 104,400 | .00177 | 17.70 | 35.78 | 1⅞ inches from end of specimen | Accepted. Also No. 45 $A_3$. |
| 16282 | 53 $A_4$ $T_2$ M | 60,000 | 106,000 | .00182 | 14.80 | 34.34 | ¾ inch from end of specimen | |
| 16308 | 53 $A_4$ $T_3$ I | 61,000 | 105,200 | .00195 | 12.00 | 20.77 | 1½ inches from end of specimen | |
| 16608 | 12 M R 54 $A_4$ $T_1$ O | 59,000 | 101,600 | .00175 | 17.85 | 42.95 | 1½ inches from end of specimen | Accepted. Also No. 53 $A_3$. |
| 16605 | 54 $A_4$ $T_3$ I | 53,000 | 95,200 | .00165 | 19.00 | 49.20 | 2 inches from end of specimen | |
| 16584 | 54 $A_4$ $T_4$ M | 53,000 | 96,400 | .00150 | 18.90 | 44.81 | 1¾ inches from end of specimen | |
| 16408 | 12 M R 55 $A_4$ $T_1$ O | 58,000 | 100,000 | .00172 | 18.90 | 42.42 | 2 inches from end of specimen | Accepted. Also No. 50 $A_3$. |
| 16385 | 55 $A_4$ $T_2$ M | 56,000 | 98,400 | .00175 | 17.80 | 41.61 | 1¾ inches from end of specimen | |
| 16407 | 55 $A_4$ $T_3$ I | 59,000 | 98,000 | .00182 | 19.60 | 51.70 | 2⅜ inches from end of specimen | |
| 16430 | 12 M R 57 $A_4$ $T_1$ O | 56,000 | 98,800 | .00172 | 18.30 | 38.76 | 2 inches from end of specimen | Accepted. Also No. 51 $A_3$. |
| 16393 | 57 $A_4$ $T_2$ M | 55,000 | 96,400 | .00167 | 18.20 | 42.69 | 2 inches from end of specimen | |
| 16424 | 57 $A_4$ T I | 53,000 | 96,000 | .00157 | 18.50 | 42.95 | 1½ inches from end of specimen | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 16438 | 12 M R 58 $A_4$ | $T_1$ O | 55,000 | 102,400 | .00182 | 15.30 | 35.21 | 1⅜ inches from end of specimen | Accepted. Also No. 52 $A_2$. |
| 16341 | 58 $A_4$ | $T_2$ M | 52,000 | 96,000 | .00167 | 18.80 | 42.15 | 1¼ inches from end of specimen | |
| 16447 | 58 $A_4$ | $T_3$ I | 54,000 | 96,000 | .00160 | 19.80 | 47.66 | 2 inches from end of specimen | |
| 16517 | 12 M R 59 $A_4$ | $T_1$ O | 59,000 | 106,800 | .00185 | 15.50 | 32.90 | 1⅜ inches from end of specimen | Accepted. Also No. 60 $A_2$. |
| 16473 | 59 $A_4$ | $T_2$ M | 52,000 | 97,600 | .00195 | 16.85 | 38.30 | 1⅛ inches from end of specimen | |
| 16518 | 59 $A_4$ | $T_3$ I | 54,000 | 96,800 | .00177 | 15.60 | 43.22 | 1¼ inches from end of specimen | |
| 16529 | 12 M R 60 $A_4$ | $T_1$ O | 60,000 | 106,800 | .00180 | 16.00 | 33.19 | 1⅞ inches from end of specimen | Accepted. Also No. 54 $A_2$. |
| 16501 | 60 $A_4$ | $T_2$ M | 55,000 | 103,600 | .00175 | 15.90 | 31.93 | 2 inches from end of specimen | |
| 16528 | 60 $A_4$ | $T_3$ I | 61,000 | 107,000 | .00180 | 15.30 | 34.92 | 1⅛ inches from end of specimen | |
| 16761 | 12 M R 56 $A_4$ | $T_1$ O | 60,000 | 103,200 | .00182 | 18.90 | 43.49 | 2 inches from end of specimen | Accepted. Also No. 56 $A_2$. |
| 16763 | 56 $A_4$ | $T_3$ I | 64,000 | 108,000 | .00185 | 16.70 | 42.69 | 1⅝ inches from end of specimen | |
| 16789 | 56 $A_8$ | $T_4$ M | 61,000 | 103,400 | .00190 | 18.70 | 43.22 | 1¼ inches from end of specimen | |
| 16809 | 12 M R 61 $A_4$ | $T_1$ O | 54,000 | 100,000 | .00157 | 20.00 | 42.95 | 2 inches from end of specimen | Accepted. Also No. 58 $A_2$. |
| 16737 | 61 $A_4$ | $T_2$ M | 54,000 | 100,800 | .00175 | 16.70 | 41.34 | 1¼ inches from end of specimen | |
| 16810 | 61 $A_4$ | $T_3$ I | 54,000 | 99,200 | .00150 | 18.00 | 42.69 | Not taken | |
| 10858 | 12 M R 62 $A_4$ | $T_1$ O | 60,000 | 106,000 | .00170 | 15.90 | 36.06 | 1⅝ inches from end of specimen | Accepted. Also No. 59 $A_2$. |
| 16829 | 62 $A_4$ | $T_2$ M | 58,000 | 104,800 | .00185 | 15.65 | 36.63 | 2 inches from end of specimen | |
| 16859 | 62 $A_4$ | $T_3$ I | 55,000 | 99,200 | .00157 | 17.90 | 40.25 | 1⅞ inches from end of specimen | |
| 16807 | 12 M R 55 $A_2$ | $T_1$ O | 53,000 | 98,000 | .00160 | 17.70 | 41.88 | 1⅛ inches from end of specimen | This hoop was originally tested as an $A_2$ hoop and was accepted; it could not be brought to size when machined and was again tested as an $A_4$ hoop. After being accepted, it was cut in two parts; these were accepted as 53 $A_2$ and 64 $A_4$. |
| 16721 | 55 $A_2$ | $T_2$ M | 53,000 | 98,400 | .00165 | 17.80 | 38.30 | 1⅝ inches from end of specimen | |
| 16808 | 55 $A_2$ | $T_3$ I | 56,000 | 100,400 | .00175 | 9.20 | 11.70 | 1 inch from end of specimen | |
| 16921 | 12 M R 63 $A_4$ | $T_1$ O | 57,000 | 103,600 | .00175 | 17.50 | 38.03 | 1⅝ inches from end of specimen | Accepted. |
| 16857 | 63 $A_4$ | $T_2$ M | 53,000 | 96,400 | .00172 | 16.75 | 40.52 | 1¾ inches from end of specimen | |
| 16922 | 63 $A_4$ | $T_3$ I | 55,000 | 97,200 | .00172 | 19.70 | 47.92 | 2 inches from end of specimen | |

TABLE XVII.—HOOPS $A_5$.

[Specimens 4 inches long between shoulders, diameter 0.564 inch, and 0.25 square inch cross section.]

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 15223 | 12 M R 31 $A_5$ | $T_1$ O | 57,000 | 102,000 | .00180 | 15.00 | 30.55 | 1 inch from end of specimen | Accepted. |
| 15262 | 31 $A_4$ | $T_2$ M | 59,000 | 99,200 | .00187 | 18.60 | 53.40 | 1⅝ inches from end of specimen | |
| 15265 | 31 $A_5$ | $T_4$ I | 64,000 | 108,240 | .00197 | 17.30 | 43.22 | 1⅞ inches from end of specimen | |
| 15269 | 12 M R 32 $A_5$ | $T_1$ O | 58,000 | 107,200 | .00180 | 15.50 | 31.78 | 2⅛ inches from end of specimen | Accepted. |
| 15280 | 32 $A_5$ | $T_2$ M | 60,000 | 107,200 | .00177 | 18.10 | 38.86 | 1¾ inches from end of specimen | |
| 15290 | 32 $A_5$ | $T_3$ I | 65,000 | 112,000 | .00200 | 15.90 | 35.78 | 2 inches from end of specimen | |
| 15664 | 12 M R 33 $A_5$ | $T_1$ O | 60,000 | 107,600 | .00200 | 12.00 | 17.59 | 1⅛ inches from end of specimen | Accepted. |
| 15646 | 33 $A_5$ | $T_2$ M | 56,000 | 104,600 | .00185 | 14.40 | 24.51 | 2 inches from end of specimen | |
| 15663 | 33 $A_4$ | $T_3$ I | 60,000 | 108,000 | .00170 | 14,45 | 26.05 | ¾ inch from end of specimen | |
| 15757 | 12 M R 34 $A_5$ | $T_1$ O | 55,000 | 96,400 | .00165 | 18.25 | 50.46 | 1½ inches from end of specimen | Accepted. |
| 15759 | 34 $A_5$ | $T_3$ I | 52,000 | 92,800 | .00160 | 18.60 | 57.48 | 1 inch from end of specimen | |
| 15728 | 34 $A_5$ | $T_4$ M | 52,000 | 92,000 | .00162 | 19.80 | 51.20 | 2 inches from end of specimen | |
| 15710 | 12 M R 35 $A_5$ | $T_1$ O | 53,000 | 97,400 | .00167 | 19.10 | 41.34 | 1⅛ inches from end of specimen | Accepted. |
| 15689 | 35 $A_5$ | $T_2$ M | 53,000 | 98,800 | .00160 | 17.90 | 35.78 | 1½ inches from end of specimen | |
| 15711 | 35 $A_5$ | $T_3$ I | 54,000 | 96,400 | .00182 | 20.30 | 45.34 | 2 inches from end of specimen | |

### *Tensile tests for 12-inch B. L. rifled mortars (cast-iron body, steel hooped)*—Continued.

TABLE XVII.—HOOPS $A_5$—Continued.

| Midvale No. | Marks on specimens. | Elastic limit per square inch of original section. | Ultimate strength per square inch of original section. | Elongation per inch under stress at elastic limit. | Ultimate elongation after rupture; per cent of original length. | Reduction in area after rupture, per cent of original section. | Position of rupture. | Remarks relative to acceptance, rejection, retreatment, etc. |
|---|---|---|---|---|---|---|---|---|
| | | *Pounds.* | *Pounds.* | | | | | |
| 15982 | 12 M R 36 $A_3$ $T_1$ O | 53,000 | 94,800 | .00165 | 19.40 | 45.60 | 2 inches from end of specimen | Accepted. |
| 15946 | 36 $A_3$ $T_2$ M | 53,000 | 95,600 | .00170 | 16.60 | 29.66 | 2 inches from end of specimen | |
| 15983 | 36 $A_3$ $T_3$ I | 52,000 | 95,600 | .00160 | 12.10 | 28.47 | ⅝ inch from end of specimen | |
| 16004 | 12 M R 37 $A_3$ $T_1$ O | 53,000 | 100,000 | .00162 | 12.40 | 20.45 | 1¼ inches from end of specimen | Accepted, |
| 15968 | 37 $A_4$ $T_2$ M | 58,000 | 103,200 | .00180 | 14.80 | 26.05 | 1⅜ inches from end of specimen | |
| 16007 | 37 $A_4$ $T_3$ I | 59,000 | 101,600 | .00177 | 13.10 | 19.83 | 1 inch from end of specimen | |
| 16210 | 12 M R 38 $A_4$ $T_1$ O | 56,000 | 100,600 | .00180 | 16.50 | 34.64 | ⅛ inch from end of specimen | Accepted. |
| 16189 | 38 $A_4$ $T_2$ M | 56,000 | 104,400 | .00180 | 12.10 | 15.65 | 1 inch from end of specimen | |
| 16211 | 38 $A_3$ $T_3$ I | 57,000 | 104,800 | .00185 | 14.80 | 32.02 | 1¼ inches from end of specimen | |
| 16344 | 12 M R 39 $A_5$ $T_1$ O | 55,000 | 102,000 | .00175 | 17.60 | 35.78 | 1¾ inches from end of specimen | Accepted. |
| 16326 | 39 $A_4$ $T_5$ M | 53,000 | 96,800 | .00167 | 16.50 | 38.30 | 1⅝ inches from end of specimen | |
| 16345 | 39 $A_3$ $T_3$ I | 57,000 | 97,000 | .00185 | 17.30 | 42.95 | ¾ inch from end of specimen | |
| 16225 | 12 M R 41 $A_3$ $T_1$ O | 56,000 | 96,400 | .00160 | 17.80 | 36.34 | 1½ inches from end of specimen | Accepted. |
| 16202 | 41 $A_4$ $T_2$ M | 53,000 | 95,200 | .00165 | 18.00 | 32.32 | 2 inches from end of specimen | |
| 16224 | 41 $A_3$ $T_3$ I | 53,000 | 95,200 | .00167 | 20.20 | 44.54 | 2 inches from end of specimen | |
| 16219 | 12 M R 40 $A_2$ $T_1$ O | 55,000 | 95,600 | .00165 | 17.70 | 38.03 | 1⅛ inches from end of specimen | Accepted. |
| 16197 | 40 $A_3$ $T_2$ M | 56,000 | 100,000 | .00182 | 12.60 | 15.00 | 1¾ inches from end of specimen | |
| 16218 | 40 $A_5$ $T_3$ I | 56,000 | 98,000 | .00172 | 9.80 | 14.67 | ⅞ inch from end of specimen | |
| 16280 | 40 $A_3$ $T_4$ I | 54,000 | 95,280 | .00157 | 13.00 | 29.96 | ⅝ inch from end of specimen | |
| 16241 | 12 M R 42 $A_3$ $T_1$ O | 56,000 | 103,600 | .00152 | 15.50 | 31.43 | 2 inches from end of specimen | Accepted. |
| 16216 | 42 $A_2$ $T_2$ M | 55,000 | 102,400 | .00157 | 16.75 | 34.92 | 1⅝ inches from end of specimen | |
| 16242 | 42 $A_3$ $T_3$ I | 57,000 | 102,000 | .00180 | 13.50 | 18.23 | ¼ inch from end of specimen | |
| 16354 | 12 M R 43 $A_5$ $T_1$ O | 53,000 | 98,000 | .00157 | 18.80 | 41.61 | 1½ inches from end of specimen | Accepted. |
| 16328 | 43 $A_3$ $T_4$ M | 54,000 | 98,400 | .00175 | 18.00 | 36.06 | 1¾ inches from end of specimen | |
| 16355 | 43 $A_3$ $T_2$ I | 56,000 | 100,000 | .00175 | 17.60 | 36.34 | 1½ inches from end of specimen | |
| 16663 | 12 M R 45 $A_3$ $T_1$ O | 58,000 | 102,400 | .00180 | 12.20 | 15.32 | 2 inches from end of specimen | Accepted. |
| 16641 | 45 $A_3$ $T_2$ M | 55,000 | 100,800 | .00175 | 16.25 | 26.66 | 1¾ inches from end of specimen | |
| 16664 | 45 $A_3$ $T_3$ I | 60,000 | 100,800 | .00190 | 12.50 | 20.77 | 1¼ inches from end of specimen | |
| 16778 | 12 M R 44 $A_3$ $T_1$ O | 55,000 | 98,000 | .00172 | 20.00 | 43.75 | 1¾ inches from end of specimen | Accepted. |
| 16783 | 44 $A_3$ $T_3$ I | 58,000 | 100,000 | .00180 | 10.00 | 12.36 | 1¾ inches from end of specimen | |
| 16742 | 44 $A_3$ $T_4$ M | 58,000 | 102,400 | .00182 | 17.70 | 41.07 | 1¾ inches from end of specimen | |
| 16750 | 12 M R 48 $A_3$ $T_1$ O | 57,000 | 105,200 | .00182 | 14.00 | 24.51 | 1¼ inches from end of specimen | Accepted. |
| 16723 | 48 $A_3$ $T_3$ M | 55,000 | 101,600 | .00160 | 13.50 | 23.58 | 1¾ inches from end of specimen | |
| 16747 | 48 $A_3$ $T_3$ I | 54,000 | 102,000 | .00172 | 15.00 | 26.66 | 2 inches from end of specimen | |

## TABLE XVIII.—HOOPS $B_1$.

[Specimens 4 inches long between shoulders, diameter 0.564 inch, and 0.25 square inch cross section. Contract of December 1, 1890.]

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 14665 | 12 M R 32 $B_1$—$T_1$ O | 66,000 | 111,000 | .00205 | 13.20 | 26.35 | 2 inches from end of specimen | Accepted. Also No. 31 $B_2$. |
| 14644 | 32 $B_1$—$T_2$ M | 63,000 | 109,200 | .00205 | 14.00 | 33.48 | 1⅜ inches from end of specimen | |
| 14663 | 32 $B_1$—$T_3$ I | 62,000 | 104,000 | .00197 | 16.20 | 45.86 | 1¾ inches from end of specimen | |
| 14803 | 12 M R 33 $B_1$—$T_1$ O | 58,000 | 106,800 | .00195 | 14.65 | 32.02 | 1⅛ inches from end of specimen | Accepted. Also No. 33 $B_2$. |
| 14783 | 33 $B_1$—$T_3$ M | 54,000 | 98,000 | .00190 | 16.85 | 41.07 | 1⅛ inches from end of specimen | |
| 14804 | 33 $B_1$—$T_4$ I | 53,000 | 96,000 | .00175 | 19.45 | 43.49 | 1⅛ inches from end of specimen | |
| 14732 | 12 M R 34 $B_1$—$T_1$ O | 57,000 | 102,800 | .00177 | 16.60 | 39.41 | 1 inch from end of specimen | Accepted. Also No. 32 $B_2$. |
| 14688 | 34 $B_1$—$T_2$ M | 55,000 | 105,200 | .00172 | 17 85 | 32.90 | 1¼ inches from end of specimen | |
| 14781 | 34 $B_1$—$T_3$ I | 59,000 | 101,600 | .00205 | 15.65 | 41.61 | 1 inch from end of specimen | |
| 14874 | 12 M R 35 $B_1$—$T_1$ O | 60,000 | 108,400 | .00187 | 16.00 | 32.32 | 2 inches from end of specimen | Accepted. Also No. 34 $B_2$. |
| 14845 | 35 $B_1$—$T_2$ M | 58,000 | 106,080 | .00192 | 15.05 | 29.37 | 1¾ inches from end of specimen | |
| 14875 | 35 $B_1$—$T_3$ I | 56,000 | 103,200 | .00182 | 15.20 | 37.19 | 1¼ inches from end of specimen | |
| 15191 | 12 M R 36 $B_1$—$T_1$ O | 62,000 | 112,000 | .00197 | 16.75 | 34.64 | 2 inches from end of specimen | Accepted. Also No. 44 $B_2$. |
| 15179 | 36 $B_1$—$T_3$ M | 58,000 | 106,000 | .00187 | 13.20 | 26.05 | 1⅛ inches from end of specimen | |
| 15201 | 36 $B_1$—$T_4$ I | 61,000 | 106,400 | .00192 | 16.00 | 39.69 | 2⅛ inches from end of specimen | |
| 14991 | 12 M R 37 $B_1$—$T_1$ O | 61,000 | 104,800 | .00195 | 17.50 | 40.79 | 2¼ inches from end of specimen | Accepted. Also No. 35 $B_2$. |
| 14977 | 37 $B_1$—$T_2$ M | 59,000 | 106,800 | .00180 | 16.50 | 33.48 | 1⅞ inches from end of specimen | |
| 14992 | 37 $B_1$—$T_3$ I | 62,000 | 106,400 | .00200 | 16.60 | 35.78 | 1¼ inches from end of specimen | |
| 15033 | 12 M R 38 $B_1$—$T_1$ O | 57,000 | 103,200 | .00195 | 14.40 | 25.74 | 2 inches from end of specimen | Accepted. Also No. 40 $B_2$. |
| 14978 | 38 $B_1$—$T_2$ M | 54,000 | 99,600 | .00177 | 15.30 | 36.34 | 2 inches from end of specimen | |
| 15044 | 38 $B_1$—$T_3$ I | 54,000 | 98,000 | .00175 | 15.60 | 40.79 | 1¾ inches from end of specimen | |
| 15017 | 12 M R 39 $B_1$—$T_1$ O | 58,000 | 100,000 | .00195 | 16.50 | 42.61 | 2 inches from end of specimen | Accepted. Also No. 36 $B_2$. |
| 14982 | 39 $B_1$—$T_2$ M | 55,000 | 96,400 | .00190 | 18.77 | 45.07 | 1¼ inches from end of specimen | |
| 15003 | 39 $B_1$—$T_3$ I | 56,000 | 95,200 | .00175 | 19.60 | 53.40 | 2 inches from end of specimen | |
| 15035 | 12 M R 40 $B_1$—$T_1$ O | 54,000 | 96,000 | .00187 | 17.80 | 46.38 | 2 inches from end of specimen | Accepted. Also No. 39 $B_2$. |
| 14986 | 40 $B_1$—$T_2$ M | 52,000 | 93,200 | .00175 | 19.80 | 47.66 | 2 inches from end of specimen | |
| 15039 | 40 $B_1$—$T_3$ I | 52,000 | 95,200 | .00175 | 21.70 | 51.94 | 1¾ inches from end of specimen | |
| 15014 | 12 M R 41 $B_1$—$T_1$ O | 62,000 | 110,400 | .00205 | 16.70 | 37.75 | 2 inches from end of specimen | Accepted. Also No. 38 $B_2$. |
| 14983 | 41 $B_1$—$T_2$ M | 57,000 | 107,000 | .00187 | 13.50 | 31.14 | 1⅛ inches from end of specimen | |
| 15038 | 41 $B_1$—$T_3$ I | 59,000 | 105,200 | .00190 | 15.50 | 38.86 | 1¾ inches from end of specimen | |
| 15059 | 12 M R 42 $B_1$—$T_1$ O | 55,000 | 101,200 | .00182 | 19.30 | 42.15 | 1⅝ inches from end of specimen | Accepted. Also No. 41 $B_2$. |
| 15019 | 42 $B_1$—$T_2$ M | 52,000 | 98,800 | .00175 | 14.80 | 25.13 | 2 inches from end of specimen | |
| 15060 | 42 $B_1$—$T_3$ I | 59,000 | 106.400 | .00185 | 15.10 | 33.48 | 1¾ inches from end of specimen | |
| 15101 | 12 M R 44 $B_1$ $T_1$ O | 60,000 | 106,400 | .00190 | 17.10 | 41.88 | 2⅛ inches from end of specimen | Accepted. Also No. 42 $B_2$. |
| 15072 | 44 $B_1$ $T_2$ M | 60,000 | 106,400 | .00197 | 17.00 | 41.61 | 2 inches from end of specimen | |
| 15104 | 44 $B_1$ $T_3$ I | 61,000 | 105,200 | .00205 | 15.80 | 41.88 | 1⅞ inches from end of specimen | |
| 15177 | 12 M R 47 $B_1$ $T_1$ O | 62,000 | 108,800 | .00195 | 13.10 | 28.77 | 2 inches from end of specimen | Accepted. Also No. 43 $B_2$. |
| 15140 | 47 $B_1$ $T_2$ M | 61,000 | 107,600 | .00182 | 13.10 | 30.55 | 1 inch from end of specimen | |
| 15181 | 47 $B_1$ $T_3$ I | 59,000 | 104,800 | .00180 | 15.40 | 39.14 | ⅞ inch from end of specimen | |
| 15334 | 12 M R 45 $B_1$ $T_1$ O | 58,000 | 104,000 | .00172 | 17.50 | 43.49 | 2 inches from end of specimen | Accepted. Also No. 46 $B_2$. |
| 15364 | 45 $B_1$ $T_3$ M | 56,000 | 102,800 | .00170 | 17.20 | 39.69 | 1⅛ inches from end of specimen | |
| 15363 | 45 $B_1$ $T_4$ I | 56,000 | 100,000 | .00175 | 19.50 | 46.38 | 2 inches from end of specimen | |
| 15365 | 12 M R 46 $B_1$ $T_1$ O | 62,000 | 106,000 | .00205 | 16.00 | 42.15 | 1¾ inches from end of specimen | Accepted. Also No. 45 $B_2$. |
| 15335 | 46 $B_1$ $T_2$ M | 61,000 | 104,000 | .00197 | 14.80 | 28.77 | 1¾ inches from end of specimen | |
| 15362 | 46 $B_1$ $T_4$ I | 63,000 | 104,400 | .00175 | 16.15 | 47.40 | 2¼ inches from end of specimen | |

*Tensile tests for 12-inch B. L. rifled mortars (cast-iron body, steel hooped)*—Continued.

TABLE XVIII.—HOOPS $B_1$—Continued.

| Midvale No. | Marks on specimens. | Elastic limit per square inch of original section. | Ultimate strength per square inch of original section. | Elongation per inch under stress at elastic limit. | Ultimate elongation after rupture, per cent of original length. | Reduction in area after rupture, per cent of original section. | Position of rupture. | Remarks relative to acceptance, rejection, retreatment, etc. |
|---|---|---|---|---|---|---|---|---|
| | | *Pounds.* | *Pounds.* | | | | | |
| 16369 | 12 M R 43 $B_1$ $T_1$ O | 64,000 | 112,000 | .00197 | 16.80 | 36.34 | 2 inches from end of specimen | Accepted. Also No. 49 $A_2$. |
| 16364 | 43 $B_1$ $T_2$ I | 61,000 | 108,000 | .00190 | 14.80 | 36.64 | 1 inch from end of specimen | |
| 16261 | 43 $B_1$ $T_4$ M | 59,000 | 111,200 | .00175 | 13.85 | 32.32 | 2 inches from end of specimen | |
| 16116 | 12 M R 49 $B_1$ $T_1$ O | 61,000 | 104,400 | .00200 | 16.30 | 38.03 | 1½ inches from end of specimen | Accepted. Also No. 47 $B_2$. |
| 16081 | 49 $B_1$ $T_2$ M | 61,000 | 108,000 | .00212 | 15.50 | 27.56 | 1¼ inches from end of specimen | |
| 16117 | 49 $B_1$ $T_3$ I | 62,000 | 104,400 | .00195 | 17.80 | 43.49 | ⅞ inch from end of specimen | |
| 16667 | 12 M R 50 $B_1$ $T_1$ O | 58,000 | 103,200 | .00172 | 17.80 | 39.41 | 1¼ inches from end of specimen | Accepted. Also No. 59 $B_2$. |
| 16665 | 50 $B_1$ $T_3$ I | 55,000 | 98,800 | .00162 | 17.00 | 42.69 | 1⅝ inches from end of specimen | |
| 16616 | 50 $B_1$ $T_4$ M | 54,000 | 100,000 | .00175 | 18.80 | 40.79 | 1⅜ inches from end of specimen | |
| 16319 | 12 M R 51 $B_1$ $T_1$ O | 54,000 | 104,000 | .00170 | 18.00 | 30.55 | ⅞ inch from end of specimen | Accepted. Also No. 49 $B_2$. |
| 16259 | 51 $B_1$ $T_2$ M | 54,000 | 102,800 | .00182 | 15.10 | 32.61 | 2 inches from end of specimen | |
| 16311 | 51 $B_1$ $T_3$ I | 53,000 | 101,200 | .00170 | 16.50 | 34.34 | 2 inches from end of specimen | |
| 16358 | 12 M R 53 $B_1$ $T_1$ O | 57,000 | 100,000 | .00185 | 17.80 | 41.61 | 1¼ inches from end of specimen | Accepted. Also No. 58 $B_2$. |
| 16295 | 53 $B_1$ $T_2$ M | 57,000 | 108,200 | .00182 | 15.90 | 34.34 | 1⅜ inches from end of specimen | |
| 16374 | 53 $B_1$ $T_3$ I | 54,000 | 96,400 | .00165 | 17.50 | 47.15 | 1¼ inches from end of specimen | |
| 16293 | 12 M R 54 $B_1$ $T_1$ O | 59,000 | 102,800 | .00187 | 16.00 | 29.96 | 1 inch from end of specimen | Accepted. Also No. 48 $B_2$. |
| 16266 | 54 $B_1$ $T_2$ M | 56,000 | 101,800 | .00180 | 16.20 | 42.95 | 1 inch from end of specimen | |
| 16294 | 54 $B_1$ $T_3$ I | 60,000 | 99,400 | .00187 | 19.30 | 54.12 | 2¼ inches from end of specimen | |
| 16348 | 12 M R 55 $B_1$ $T_1$ O | 55,000 | 97,600 | .00180 | 19.70 | 43.75 | 1⅝ inches from end of specimen | Accepted. Also No. 50 $B_2$. |
| 16310 | 55 $B_1$ $T_2$ M | 57,000 | 100,000 | .00180 | 20.30 | 45.07 | 1⅜ inches from end of specimen | |
| 16349 | 55 $B_1$ $T_3$ I | 65,000 | 102,000 | .00197 | 17.80 | 49.46 | 1½ inches from end of specimen | |
| 16370 | 12 M R 56 $B_1$ $T_1$ O | 58,000 | 101,200 | .00155 | 16.00 | 33.48 | 1¼ inches from end of specimen | Accepted. Also No. 52 $B_2$. |
| 16324 | 56 $B_1$ $T_2$ M | 52,000 | 96,000 | .00157 | 14.80 | 26.05 | 2 inches from end of specimen | |
| 16365 | 56 $B_1$ $T_3$ I | 53,000 | 96,000 | .00170 | 17.70 | 44.54 | 1⅝ inches from end of specimen | |
| 16366 | 12 M R 57 $B_1$ $T_1$ O | 59,000 | 104,000 | .00187 | 17.60 | 36.84 | 2¼ inches from end of specimen | Accepted. Also No. 51 $B_2$. |
| 16325 | 57 $B_1$ $T_2$ M | 59,000 | 103,200 | .00185 | 18.30 | 38.86 | 2¼ inches from end of specimen | |
| 16367 | 57 $B_1$ $T_3$ I | 58,000 | 101,600 | .00180 | 16.00 | 40.79 | ⅞ inch from end of specimen | |
| 16398 | 12 M R 58 $B_1$ $T_1$ O | 58,000 | 105,200 | .00162 | 17.70 | 39.14 | 1¼ inches from end of specimen | Accepted. Also No. 54 $B_2$. |
| 16387 | 58 $B_1$ $T_2$ M | 53,000 | 99,200 | .00170 | 16.40 | 32.02 | 1⅜ inches from end of specimen | |
| 16405 | 58 $B_1$ $T_3$ I | 55,000 | 97,600 | .00172 | 18.80 | 48.44 | 1⅜ inches from end of specimen | |
| 16485 | 12 M R 60 $B_1$ $T_1$ O | 53,000 | 95,200 | .00147 | 20.50 | 44.28 | 2 inches from end of specimen | Accepted. Also No. 55 $B_2$. |
| 16482 | 60 $B_1$ $T_2$ M | 52,000 | 97,600 | .00167 | 15.90 | 38.58 | 2 inches from end of specimen | |
| 16462 | 60 $B_1$ $T_3$ I | 52,000 | 95,200 | .00150 | 16.60 | 46.38 | 1½ inches from end of specimen | |
| 16499 | 12 M R 62 $B_1$ $T_1$ O | 50,000 | 101,600 | .00180 | 17.10 | 38.58 | 1⅝ inches from end of specimen | Accepted. Also No. 56 $B_2$. |
| 16459 | 62 $B_1$ $T_2$ M | 54,000 | 98,800 | .00162 | 16.15 | 36.84 | 1⅜ inches from end of specimen | |
| 16502 | 62 $B_1$ $T_3$ I | 56,000 | 97,600 | .00167 | 17.80 | 47.66 | 1½ inches from end of specimen | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 16509 | 12 M R 63 $B_1$ $T_1$ O | 55,000 | 100,000 | .00165 | 17.50 | 38.58 | 2 inches from end of specimen | Accepted. Also No. 57 $B_6$. |
| 16481 | 63 $B_1$ $T_2$ M | 52,000 | 99,200 | .00170 | 16.05 | 34.92 | 1½ inches from end of specimen | |
| 16510 | 63 $B_1$ $T_3$ I | 54,000 | 95,200 | .00170 | 20.20 | 50.76 | 2¼ inches from end of specimen | |
| 16586 | 12 M R 65 $B_1$ $T_1$ O | 55,000 | 101,600 | .00170 | 17.50 | 35.78 | 1¾ inches from end of specimen | Accepted. Also No. 58 $B_6$. |
| 16568 | 65 $B_1$ $T_2$ M | 54,000 | 100,000 | .00175 | 15.30 | 38.58 | 1½ inches from end of specimen | |
| 16587 | 65 $B_1$ $T_3$ I | 54,000 | 96,000 | .00157 | 17.40 | 43.75 | 1¾ inches from end of specimen | |
| 16666 | 12 M R 66 $B_1$ $T_1$ O | 60,000 | 107,200 | .00200 | 14.90 | 31.48 | 2 inches from end of specimen | Accepted. Also No. 60 $B_6$. |
| 16649 | 66 $B_1$ $T_2$ M | 59,000 | 106,000 | .00175 | 16.50 | 32.90 | 2 inches from end of specimen | |
| 16668 | 66 $B_1$ $T_3$ I | 62,000 | 106,000 | .00190 | 18.00 | 36.34 | 1 inch from end of specimen | |
| 16867 | 12 M R 67 $B_1$ $T_1$ O | 56,000 | 100,000 | .00162 | 18.10 | 39.96 | 1⅞ inches from end of specimen | Accepted. Also No. 62 $B_6$. |
| 16828 | 67 $B_1$ $T_2$ M | 54,000 | 100,800 | .00180 | 17.15 | 37.19 | 2 inches from end of specimen | |
| 16868 | 67 $B_1$ $T_3$ I | 58,000 | 99,600 | .00160 | 17.80 | 46.89 | 1½ inches from end of specimen | |
| 16805 | 12 M R 52 $B_1$ $T_1$ O | 56,000 | 105,600 | .00165 | 16.00 | 34.92 | 1¾ inches from end of specimen | Accepted. Also No. 61 $B_6$. |
| 16762 | 52 $B_1$ $T_2$ M | 59,000 | 105,600 | .00185 | 17.50 | 36.06 | 1½ inches from end of specimen | |
| 16806 | 52 $B_1$ $T_3$ I | 67,000 | 109,600 | .00202 | 15.00 | 46.12 | 1½ inches from end of specimen | |

### TABLE XIX.—HOOPS $B_4$.

[Specimens 3 inches long between shoulders, diameter 0.564 inch, and 0.25 square inch cross section.]

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 14424 | 12 M R 32 $B_4$—$T_1$ O | 57,000 | 108,200 | .00177 | 15.00 | 25.74 | 2 inches from end of specimen | Accepted. Also No. 32 $B_6$. |
| 14373 | 32 $B_4$—$T_2$ M | 60,000 | 104,600 | .00182 | 15.50 | 39.69 | 1 inch from end of specimen | |
| 14425 | 32 $B_4$—$T_3$ I | 59,000 | 105,200 | .00177 | 17.30 | 42.42 | 1 inch from end of specimen | |
| 14438 | 12 M R 34 $B_4$—$T_1$ O | 59,000 | 104,000 | .00172 | 16.60 | 34.92 | 1¾ inches from end of specimen | Accepted. Also No. 33 $B_6$. |
| 14399 | 34 $B_4$—$T_2$ M | 54,000 | 99,600 | .00160 | 18.00 | 39.14 | 1¼ inches from end of specimen | |
| 14436 | 34 $B_4$—$T_3$ I | 61,000 | 106,400 | .00187 | 16.70 | 39.96 | ¾ inch from end of specimen | |
| 14495 | 12 M R 35 $B_4$—$T_1$ O | 59,000 | 104,000 | .00185 | 16.50 | 32.02 | 1¾ inches from end of specimen | Accepted. Also No. 34 $B_6$. |
| 14432 | 35 $B_4$—$T_2$ M | 55,000 | 100,000 | .00177 | 17.50 | 37.75 | 1½ inches from end of specimen | |
| 14496 | 35 $B_4$—$T_3$ I | 58,000 | 100,000 | .00185 | 16.80 | 47.15 | 1¾ inches from end of specimen | |
| 14640 | 12 M R 36 $B_4$—$T_1$ O | 54,000 | 96,800 | .00172 | 20.70 | 43.49 | 2 inches from end of specimen | Accepted. Also No. 35 $B_6$. |
| 14616 | 36 $B_4$—$T_2$ M | 57,000 | 100,800 | .00187 | 18.80 | 40.25 | 2 inches from end of specimen | |
| 14639 | 36 $B_4$—$T_3$ I | 57,000 | 100,000 | .00182 | 18.30 | 44.54 | 1 inch from end of specimen | |
| 14664 | 12 M R 37 $B_4$—$T_1$ O | 57,000 | 105,600 | .00177 | 14.70 | 25.13 | 1¾ inches from end of specimen | Accepted. Also No. 36 $B_6$. |
| 14645 | 37 $B_4$—$T_2$ M | 56,000 | 107,200 | .00180 | 14.30 | 28.44 | 1½ inches from end of specimen | |
| 14666 | 37 $B_4$—$T_3$ I | 57,000 | 108,000 | .00182 | 14.40 | 29.66 | 1⅜ inches from end of specimen | |
| 14698 | 12 M R 38 $B_4$—$T_1$ O | 59,000 | 107,200 | .00195 | 15.20 | 29.07 | 2½ inches from end of specimen | Accepted. Also No. 37 $B_6$. |
| 14662 | 38 $B_4$—$T_2$ M | 56,000 | 103,600 | .00182 | 15.50 | 36.63 | 1¾ inches from end of specimen | |
| 14687 | 38 $B_4$—$T_3$ I | 59,000 | 107,200 | .00195 | 17.05 | 36.91 | 1⅞ inches from end of specimen | |
| 14884 | 12 M R 39 $B_4$—$T_1$ O | 57,000 | 108,200 | .00182 | 16.30 | 36.34 | 1⅞ inches from end of specimen | Accepted. Also No. 38 $B_6$. |
| 14856 | 39 $B_4$—$T_2$ M | 54,000 | 100,800 | .00172 | 17.10 | 32.32 | 2¼ inches from end of specimen | |
| 14885 | 39 $B_4$—$T_3$ I | 58,000 | 105,600 | .00192 | 16.20 | 35.49 | 1¾ inches from end of specimen | |
| 14899 | 12 M R 40 $B_4$—$T_1$ O | 62,000 | 106,400 | .00200 | 16.00 | 38.03 | 1¾ inches from end of specimen | Accepted. Also No. 39 $B_6$. |
| 14857 | 40 $B_4$—$T_2$ M | 57,000 | 106,000 | .00185 | 16.10 | 29.96 | 2 inches from end of specimen | |
| 14900 | 40 $B_4$—$T_3$ I | 62,000 | 108,400 | .00200 | 16.40 | 36.06 | 2 inches from end of specimen | |
| 15162 | 12 M R 33 $B_4$—$T_1$ O | 61,000 | 108,800 | .00197 | 16.80 | 42.42 | 2⅜ inches from end of specimen | Accepted. Also No. 46 $B_6$. |
| 15200 | 33 $B_4$—$T_2$ M | 59,000 | 106,400 | .00180 | 15.40 | 31.23 | 1⅝ inches from end of specimen | |
| 15221 | 33 $B_4$—$T_4$ I | 66,000 | 108,800 | .00210 | 17.40 | 46.89 | 2¼ inches from end of specimen | |

### *Tensile tests for 12-inch B. L. rifled mortars (cast-iron body, steel hooped)*—Continued.

TABLE XIX—HOOPS $B_4$—Continued.

| Midvale No. | Marks on specimens. | Elastic limit per square inch of original section. | Ultimate strength per square inch of original section. | Elongation per inch under stress at elastic limit. | Ultimate elongation after rupture, per cent of original length. | Reduction in area after rupture, per cent of original section. | Position of rupture. | Remarks relative to acceptance, rejection, retreatment, etc. |
|---|---|---|---|---|---|---|---|---|
| | | *Pounds.* | *Pounds.* | | | | | |
| 14995 | 12 M R 41 $B_4$—$T_1$ O | 59,000 | 104,000 | .00180 | 16.40 | 41.07 | ⅞ inch from end of specimen | Accepted. Also No. 40 $B_3$. |
| 14901 | 41 $B_4$—$T_2$ M | 60,000 | 104,000 | .00197 | 15.10 | 37.75 | ⅞ inch from end of specimen | |
| 15015 | 41 $B_4$—$T_3$ I | 65,000 | 108,800 | .00212 | 16.10 | 40.79 | 1⅛ inches from end of specimen | |
| 15160 | 12 M R 42 $B_4$—$T_1$ O | 55,000 | 99,600 | .00175 | 17.70 | 39.96 | 1⅞ inches from end of specimen | Accepted. Also No. 42 $B_3$. |
| 15178 | 42 $B_4$—$T_2$ M | 52,000 | 97,600 | .00180 | 18.00 | 38.03 | 1¾ inches from end of specimen | |
| 15180 | 42 $B_4$—$T_4$ I | 57,000 | 102,400 | .00185 | 14.70 | 37.19 | ⅝ inch from end of specimen | |

[Specimens 4 inches long between shoulders, diameter 0.564 inch, and 0.25 square inch cross section.]

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 15045 | 12 M R 43 $B_4$ $T_1$ O | 64,000 | 106,800 | .00205 | 18.00 | 45.07 | 1½ inches from end of specimen | Accepted. Also No. 48 $B_1$. |
| 14987 | 43 $B_4$ $T_2$ M | 53,000 | 97,200 | .00175 | 18.10 | 46.64 | 1¼ inches from end of specimen | |
| 15058 | 43 $B_4$ $T_3$ I | 63,000 | 103,200 | .00205 | 17.80 | 50.70 | 1¾ inches from end of specimen | |
| 15021 | 12 M R 44 $B_4$ $T_1$ O | 58,000 | 104,000 | .00182 | 13.40 | 19.83 | 1¾ inches from end of specimen | Accepted. Also No. 41 $B_3$. |
| 14981 | 44 $B_4$ $T_2$ M | 55,000 | 102,800 | .00165 | 13.20 | 21.41 | 1½ inches from end of specimen | |
| 15040 | 44 $B_4$ $T_3$ I | 61,000 | 108,000 | .00195 | 16.90 | 39.96 | 2 inches from end of specimen | |
| 15064 | 12 M R 45 $B_4$ $T_1$ O | 62,000 | 106,800 | .00200 | 16.60 | 32.32 | 1¼ inches from end of specimen | Accepted. Also No. 43 $B_3$. |
| 15030 | 45 $B_4$ $T_2$ M | 58,000 | 109,200 | .00185 | 14.00 | 29.96 | 2 inches from end of specimen | |
| 15069 | 45 $B_4$ $T_3$ I | 64,000 | 110,800 | .00197 | 13.10 | 32.61 | 1 inch from end of specimen | |
| 15109 | 12 M R 46 $B_4$ $T_1$ O | 59,000 | 108,000 | .00205 | 16.50 | 27.56 | 1⅞ inches from end of specimen | Accepted. Also No. 45 $B_3$. |
| 15080 | 46 $B_4$ $T_2$ M | 59,000 | 108,400 | .00200 | 15.00 | 25.43 | 1¾ inches from end of specimen | |
| 15108 | 46 $B_4$ $T_3$ I | 61,000 | 111,600 | .00200 | 13.80 | 34.05 | ⅝ inch from end of specimen | |
| 15093 | 12 M R 47 $B_4$ $T_1$ O | 64,000 | 110,800 | .00205 | 14.40 | 27.56 | 2 inches from end of specimen | Accepted. Also No. 44 $B_3$. |
| 15073 | 47 $B_4$ $T_2$ M | 68,000 | 112,000 | .00212 | 14.55 | 34.92 | 1½ inches from end of specimen | |
| 15105 | 47 $B_4$ $T_3$ I | 58,000 | 108,400 | .00190 | 13.20 | 35.49 | ⅝ inch from end of specimen | |
| 16337 | 12 M R 48 $B_4$ $T_1$ O | 62,000 | 105,600 | .00190 | 17.30 | 40.25 | 2 inches from end of specimen | Accepted. Also No. 49 $B_3$. |
| 16338 | 48 $B_4$ $T_3$ I | 63,000 | 107,600 | .00196 | 16.80 | 36.91 | 2 inches from end of specimen | |
| 16260 | 48 $B_4$ $T_4$ M | 59,000 | 106,800 | .00190 | 16.70 | 36.34 | 1⅞ inches from end of specimen | |
| 16291 | 12 M R 49 $B_4$ $T_1$ O | 58,000 | 99,600 | .00180 | 19.70 | 45.60 | 2 inches from end of specimen | Accepted. Also No. 50 $B_1$. |
| 16256 | 49 $B_4$ $T_2$ M | 57,000 | 99,400 | .00182 | 19.30 | 46.88 | 1¼ inches from end of specimen | |
| 16292 | 49 $B_4$ $T_3$ I | 64,000 | 106,800 | .00202 | 16.80 | 43.75 | 1¼ inches from end of specimen | |
| 16263 | 12 M R 50 $B_4$ $T_1$ O | 60,000 | 110,800 | .00200 | 15.20 | 28.47 | 2 inches from end of specimen | Accepted. Also No. 47 $B_3$. |
| 16227 | 50 $B_4$ $T_2$ M | 59,000 | 110,000 | .00195 | 15.40 | 27.56 | 1⅝ inches from end of specimen | |
| 16264 | 50 $B_4$ $T_3$ I | 62,000 | 111,200 | .00202 | 13.80 | 28.17 | ⅝ inch from end of specimen | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 16346 | 12 M R 51 $B_4$ | $T_1$ O | 53,000 | 102,400 | .00172 | 13.10 | 24.51 | 2 inches from end of specimen | Accepted. Also No. 50 $B_3$. |
| 16285 | 51 $B_4$ | $T_2$ M | 53,000 | 101,000 | .00157 | 15.75 | 29.37 | ¾ inch from end of specimen | |
| 16347 | 51 $B_4$ | $T_3$ I | 59,000 | 107,600 | .00192 | 15.20 | 32.02 | 1 inch from end of specimen | |
| 16377 | 12 M R 52 $B_4$ | $T_1$ O | 54,000 | 99,200 | .00172 | 18.85 | 36.91 | 1½ inches from end of specimen | Accepted. Also No. 52 $B_3$. |
| 16322 | 52 $B_4$ | $T_2$ M | 53,000 | 97,600 | .00170 | 19.60 | 42.15 | 1½ inches from end of specimen | |
| 16378 | 52 $B_4$ | $T_3$ I | 54,000 | 96,400 | .00175 | 19.00 | 47.66 | 1¼ inches from end of specimen | |
| 16375 | 12 M R 53 $B_4$ | $T_1$ O | 53,000 | 99,600 | .00172 | 18.20 | 36.91 | 1¾ inches from end of specimen | Accepted. Also No. 48 $B_3$. |
| 16321 | 53 $B_4$ | $T_2$ M | 54,000 | 102,400 | .00172 | 18.50 | 35.49 | 1¼ inches from end of specimen | |
| 16376 | 53 $B_4$ | $T_3$ I | 59,000 | 102,000 | .00175 | 18.10 | 42.42 | 1¾ inches from end of specimen | |
| 16381 | 12 M R 54 $B_4$ | $T_1$ O | 55,000 | 97,600 | .00182 | 19.70 | 42.69 | 2 inches from end of specimen | Accepted. Also No. 61 $B_3$. |
| 16323 | 54 $B_4$ | $T_2$ M | 53,000 | 100,000 | .00160 | 17.80 | 36.06 | 1¾ inches from end of specimen | |
| 16388 | 54 $B_4$ | $T_3$ I | 54,000 | 97,200 | .00162 | 17.60 | 42.69 | 1¼ inches from end of specimen | |
| 16356 | 12 M R 55 $B_4$ | $T_1$ O | 57,000 | 102,000 | .00180 | 16.80 | 39.96 | 1½ inches from end of specimen | Accepted. Also No. 51 $B_3$. |
| 16320 | 55 $B_4$ | $T_2$ M | 55,000 | 103,600 | .00167 | 15.90 | 32.61 | 1½ inches from end of specimen | |
| 16357 | 55 $B_4$ | $T_3$ I | 60,000 | 107,200 | .00185 | 16.10 | 38.03 | 1 inch from end of specimen | |
| 16446 | 12 M R 57 $B_4$ | $T_1$ O | 53,000 | 96,000 | .00157 | 22.20 | 42.42 | 1¾ inches from end of specimen | Accepted. Also No. 53 $B_3$. |
| 16389 | 57 $B_4$ | $T_2$ M | 52,000 | 95,000 | .00157 | 19.50 | 42.95 | 1¾ inches from end of specimen | |
| 16420 | 57 $B_4$ | $T_3$ I | 57,000 | 99,200 | .00170 | 17.20 | 44.54 | 2½ inches from end of specimen | |
| 16403 | 12 M R 58 $B_4$ | $T_1$ O | 55,000 | 100,000 | .00175 | 17.40 | 39.41 | 1½ inches from end of specimen | Accepted. Also No. 54 $B_3$. |
| 16431 | 58 $B_4$ | $T_2$ M | 53,000 | 99,200 | .00172 | 19.40 | 37.47 | 1½ inches from end of specimen | |
| 16494 | 58 $B_4$ | $T_3$ I | 57,000 | 103,200 | .00167 | 16.70 | 38.30 | 1 inch from end of specimen | |
| 16544 | 12 M R 59 $B_4$ | $T_1$ O | 56,000 | 101,600 | .00162 | 17.50 | 40.79 | 2¼ inches from end of specimen | Accepted. Also No. 55 $B_3$. |
| 16508 | 59 $B_4$ | $T_2$ M | 54,000 | 98,800 | .00170 | 17.70 | 36.91 | 1¾ inches from end of specimen | |
| 16545 | 59 $B_4$ | $T_3$ I | 58,000 | 101,600 | .00180 | 16.90 | 42.95 | 1¾ inches from end of specimen | |
| 16569 | 12 M R 60 $B_4$ | $T_1$ O | 60,000 | 106,800 | .00192 | 15.50 | 32.02 | 2 inches from end of specimen | Accepted. Also No. 56 $B_3$. |
| 16530 | 60 $B_4$ | $T_2$ M | 58,000 | 106,600 | .00182 | 16.00 | 32.82 | 1½ inches from end of specimen | |
| 16570 | 60 $B_4$ | $T_3$ I | 60,000 | 108,800 | .00192 | 15.00 | 29.96 | 1¾ inches from end of specimen | |
| 16656 | 12 M R 61 $B_4$ | $T_1$ O | 59,000 | 107,600 | .00187 | 15.80 | 33.48 | 2 inches from end of specimen | Accepted. Also No. 58 $B_3$. |
| 16604 | 61 $B_4$ | $T_2$ M | 55,000 | 104,000 | .00175 | 14.30 | 29.66 | ½ inch from end of specimen | |
| 16657 | 61 $B_4$ | $T_3$ I | 59,000 | 106,400 | .00200 | 16.20 | 34.92 | 1 inch from end of specimen | |
| 16599 | 12 M R 62 $B_4$ | $T_1$ O | 58,000 | 100,000 | .00187 | 19.00 | 47.15 | 2½ inches from end of specimen | Accepted. Also No. 57 $B_3$. |
| 16574 | 62 $B_4$ | $T_2$ M | 57,000 | 100,000 | .00182 | 19.00 | 44.54 | 2 inches from end of specimen | |
| 16600 | 62 $B_4$ | $T_3$ I | 60,000 | 100,000 | .00200 | 17.50 | 48.18 | 1¾ inches from end of specimen | |
| 16738 | 12 M R 63 $B_4$ | $T_1$ O | 56,000 | 98,000 | .00175 | 18.40 | 42.15 | 2 inches from end of specimen | Accepted. Also No. 59 $B_3$. |
| 16709 | 63 $B_4$ | $T_2$ M | 55,000 | 100,000 | .00165 | 17.20 | 39.14 | 1¾ inches from end of specimen | |
| 16736 | 63 $B_4$ | $T_3$ I | 57,000 | 97,600 | .00175 | 16.80 | 50.70 | 1½ inches from end of specimen | |
| 16901 | 12 M R 56 $B_4$ | $T_1$ O | 55,000 | 98,800 | .00157 | 17.80 | 36.91 | 1¾ inches from end of specimen | Accepted. Also No. 60 $B_3$. |
| 16856 | 56 $B_4$ | $T_2$ M | 54,000 | 95,200 | .00150 | 17.80 | 45.86 | 1 inch from end of specimen | |
| 16898 | 56 $B_4$ | $T_4$ I | 56,000 | 97,200 | .00175 | 18.40 | 49.46 | 1 inch from end of specimen | |

## TABLE XX.—HOOPS $B_5$.

[Specimens 4 inches long between shoulders, diameter 0.564 inch, and 0.25 square inch cross section. Contract of December 1, 1890.]

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 14479 | 12 M R 31 $B_5$ | $T_1$ O | 55,000 | 102,800 | .00180 | 18.20 | 38.86 | 2 inches from end of specimen | Accepted. Also No. 32 $B_5$. |
| 14433 | 31 $B_5$ | $T_2$ M | 58,000 | 100,800 | .00175 | 20.10 | 43.22 | 2½ inches from end of specimen | |
| 14483 | 31 $B_5$ | $T_3$ I | 58,000 | 104,400 | .00170 | 16.95 | 37.19 | 1¾ inches from end of specimen | |
| 15022 | 12 M R 33 $B_5$ | $T_1$ O | 56,000 | 102,800 | .00187 | 17.50 | 39.41 | 2 inches from end of specimen | Accepted. Also No. 41 $B_5$. |
| 14949 | 33 $B_5$ | $T_2$ M | 53,000 | 100,000 | .00177 | 17.50 | 36.91 | 1¼ inches from end of specimen | |
| 14998 | 33 $B_5$ | $T_3$ I | 54,000 | 100,000 | .00167 | 15.20 | 34.92 | 1 inch from end of specimen | |

*Tensile tests for 12-inch B. L. rifled mortars (cast-iron body, steel hooped)*—Continued.

TABLE XX.—HOOPS $B_5$—Continued.

| Midvale No. | Marks on specimens. | Elastic limit per square inch of original section. | Ultimate strength per square inch of original section. | Elongation per inch under stress at elastic limit. | Ultimate elongation after rupture, per cent of original length. | Reduction in area after rupture, per cent of original section. | Position of rupture. | Remarks relative to acceptance, rejection, retreatment, etc. |
|---|---|---|---|---|---|---|---|---|
| | | *Pounds.* | *Pounds.* | | | | | |
| 14993 | 12 M R 34 $B_5$ $T_1$ O | 61.000 | 104,000 | .00195 | 16.90 | 46.89 | 1½ inches from end of specimen | Accepted. Also No. 40 $B_6$. |
| 14976 | 34 $B_5$ $T_2$ M | 62.000 | 108,600 | .00197 | 13.80 | 34.92 | 1¼ inches from end of specimen | |
| 14994 | 34 $B_5$ $T_3$ I | 58,000 | 104,400 | .00187 | 18.30 | 39.69 | 2 inches from end of specimen | |
| 15159 | 12 M R 35 $B_5$ $T_1$ O | 60.000 | 107,200 | .00200 | 16.30 | 38.30 | 2 inches from end of specimen | Accepted. Also No. 46 $B_6$. |
| 15127 | 35 $B_5$ $T_2$ M | 56,000 | 105,600 | .00187 | 16.20 | 36.63 | 1¾ inches from end of specimen | |
| 15151 | 35 $B_5$ $T_4$ I | 61.000 | 109,200 | .00192 | 16.00 | 37.47 | 1⅜ inches from end of specimen | |
| 15025 | 12 M R 36 $B_5$ $T_1$ O | 55,000 | 101,200 | .00182 | 18.00 | 38.30 | 1½ inches from end of specimen | Accepted. Also No. 42 $B_6$. |
| 14984 | 36 $B_5$ $T_2$ M | 55,000 | 101,200 | .00172 | 17.50 | 38.30 | 2 inches from end of specimen | |
| 15016 | 36 $B_5$ $T_3$ I | 59,000 | 104,800 | .00195 | 15.30 | 37.75 | 1⅛ inches from end of specimen | |
| 15032 | 12 M R 37 $B_5$ $T_1$ O | 57,000 | 104,800 | .00182 | 16.90 | 33.76 | 2 inches from end of specimen | Accepted. Also No. 44 $B_6$. |
| 14990 | 37 $B_5$ $T_2$ M | 53.000 | 103,200 | .00175 | 17.60 | 32.61 | 1⅜ inches from end of specimen | |
| 15037 | 37 $B_5$ $T_3$ I | 63,000 | 108,400 | .00200 | 17.00 | 41.34 | 1¼ inches from end of specimen | |
| 15020 | 12 M R 38 $B_5$ $T_1$ O | 56,000 | 101,600 | .00180 | 16.35 | 37.75 | 1½ inches from end of specimen | Accepted. Also No. 43 $B_6$. |
| 14988 | 38 $B_5$ $T_2$ M | 55,000 | 101,200 | .00177 | 18.30 | 34.64 | 1⅞ inches from end of specimen | |
| 15031 | 38 $B_5$ $T_3$ I | 61,000 | 106,800 | .00202 | 16.80 | 41.34 | 1 inch from end of specimen | |
| 15061 | 12 M R 39 $B_5$ $T_1$ O | 58,000 | 107,600 | .00180 | 14.50 | 35.49 | ⅞ inch from end of specimen | Accepted. Also No. 45 $B_6$. |
| 15024 | 39 $B_5$ $T_2$ M | 55.000 | 102.800 | .00180 | 17.60 | 39.69 | 1½ inches from end of specimen | |
| 15062 | 39 $B_5$ $T_3$ I | 57.000 | 105,600 | .00190 | 16.60 | 37.47 | 2¼ inches from end of specimen | |
| 16379 | 12 M R 47 $B_5$ $T_1$ O | 58.000 | 107.600 | .00182 | 15.40 | 34.92 | 1¾ inches from end of specimen | Accepted. Also No. 49 $B_6$. |
| 16327 | 47 $B_5$ $T_2$ M | 56.000 | 106,800 | .00180 | 16.80 | 28.77 | 2 inches from end of specimen | |
| 16380 | 47 $B_5$ $T_3$ I | 59,000 | 108,800 | .00187 | 14.50 | 34.05 | 1⅛ inches from end of specimen | |
| 16411 | 12 M R 48 $B_5$ $T_1$ O | 59,000 | 109,600 | .00177 | 13.90 | 30.55 | 1¼ inches from end of specimen | Accepted. Also No. 50 $B_6$. |
| 16391 | 48 $B_5$ $T_2$ M | 57,000 | 109,200 | .00195 | 13.80 | 26.35 | 1¾ inches from end of specimen | |
| 16412 | 48 $B_5$ $T_3$ I | 60,000 | 111,200 | .00187 | 15.40 | 31.73 | 2 inches from end of specimen | |
| 16546 | 12 M R 51 $B_5$ $T_1$ O | 60,000 | 105.200 | .00192 | 17.30 | 34.64 | 1¾ inches from end of specimen | Accepted. Also No. 47 $B_6$. |
| 16515 | 51 $B_5$ $T_2$ M | 58,000 | 106,000 | .00185 | 14.50 | 32.90 | 2¼ inches from end of specimen | |
| 16567 | 51 $B_5$ $T_3$ I | 62,000 | 109,200 | .00197 | 14.35 | 33.48 | 1 inch from end of specimen | |
| 16873 | 12 M R 53 $B_5$ $T_1$ O | 59,000 | 105,600 | .00160 | 16.15 | 33.76 | 1⅜ inches from end of specimen | Accepted. Also No. 54 $B_6$. |
| 16849 | 53 $B_5$ $T_2$ M | 56,000 | 106.000 | .00175 | 16.20 | 33.48 | 1¾ inches from end of specimen | |
| 16883 | 53 $B_5$ $T_3$ I | 60,000 | 109,600 | .00187 | 14.60 | 34.92 | 1 inch from end of specimen | |

## TABLE XXI.—BREECH MECHANISM.

[Specimens 3 inches long between shoulders, diameter 0.564 inch, and 0.25 square inch cross section.]

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | *Translating rollers.* | | | | | | | | |
| 14537 | 12 M R 31 T R—L, M | 55,000 | 95,600 | .00150 | 21.20 | 45.60 | 1⅜ inches from end of specimen | Accepted. | Also 32 and 33. |
| 14551 | 34 T R—L, M | 58,000 | 95,600 | .00200 | 22.40 | 52.43 | 1¼ inches from end of specimen | Accepted. | Also 35 and 36. |
| 14553 | 37 T R—L, M | 57,000 | 94,800 | .00173 | 21.50 | 49.66 | 1⅜ inches from end of specimen | Accepted. | Also 38 and 39. |
| 14519 | 40 T R—L, M | 59,000 | 95,600 | .00187 | 20.00 | 51.70 | 1 inch from end of specimen | Accepted. | Also 41 and 42. |
| 14559 | 43 T R—L, M | 54,000 | 92,000 | .00167 | 22.50 | 49.96 | 1⅜ inches from end of specimen | Accepted. | Also 44 and 45. |
| 14550 | 48 T R—L, M | 54,000 | 96,800 | .00180 | 19.13 | 45.86 | 1 inch from end of specimen | Accepted. | Also 46 and 47. |
| 14558 | 50 T R—L, M | 54,000 | 91,600 | .00167 | 24.00 | 52.91 | 1⅜ inches from end of specimen | Accepted. | Also 49 and 51. |
| 14552 | 52 T R—L, M | 57,000 | 97,200 | .00203 | 19.60 | 43.73 | 1¼ inches from end of specimen | Accepted. | Also 53. |
| 14560 | 54 T R—L, M | 55,000 | 91,200 | .00167 | 21.60 | 51.45 | 1¼ inches from end of specimen | Accepted. | Also 55 and 56. |
| 14561 | 57 T R—L, M | 56,000 | 93,600 | .00173 | 20.40 | 47.92 | 1 inch from end of specimen | Accepted. | Also 58. |
| 14556 | 59 T R—L, M | 54,000 | 94,400 | .00153 | 20.00 | 46.64 | ⅞ inch from end of specimen | Accepted. | Also 60 and 61. |
| 14573 | 62 T R—L, M | 59,000 | 96,800 | .00190 | 21.40 | 50.20 | 1¼ inches from end of specimen | Accepted. | Also 63 and 64. |
| 14553 | 65 T R—L, M | 55,000 | 95,600 | .00170 | 19.93 | 44.02 | ⅞ inch from end of specimen | Accepted. | Also 66 and 67. |
| 14554 | 68 T R—L, M | 53,000 | 94,400 | .00180 | 20.73 | 47.40 | 1¼ inches from end of specimen | Accepted. | Also 69 and 70. |
| 14562 | 71 T R—L, M | 53,000 | 91,600 | .00163 | 21.30 | 49.96 | 1 inch from end of specimen | Accepted. | Also 72 and 73. |
| | *Hinge pins.* | | | | | | | | |
| 14557 | 12 M R 31 H P—L, M | 50,000 | 90,000 | .00177 | 23.60 | 53.40 | 1¼ inches from end of specimen | Accepted. | Also 32 and 33. |
| 14588 | 31 H P—L, M | 54,000 | 91,800 | .00187 | 22.10 | 53.64 | ⅞ inch from end of specimen | Accepted. | Also 35 and 36. |
| 14600 | 38 H P—L, M | 57,000 | 92,000 | .00180 | 23.00 | 53.16 | 1¼ inches from end of specimen | Accepted. | Also 37 and 39. |
| 14589 | 41 H P—L, M | 60,000 | 94,800 | .00200 | 22.20 | 53.88 | 1 inch from end of specimen | Accepted. | Also 40. |
| 14597 | 42 H P—L, M | 52,000 | 92,000 | .00170 | 19.53 | 47.40 | ⅞ inch from end of specimen | Accepted. | Also 43 and 44. |
| 14599 | 45 H P—L, M | 60,000 | 94,400 | .00193 | 20.80 | 54.36 | 1 inch from end of specimen | Accepted. | Also 46. |
| 14577 | 49 H P—L, M | 55,000 | 92,400 | .00193 | 20.93 | 50.20 | 1¼ inches from end of specimen | Accepted. | Also 48 and 50. |
| 14590 | 51 H P—L, M | 55,000 | 91,400 | .00177 | 20.60 | 52.91 | ⅞ inch from end of specimen | Accepted. | Also 52 and 53. |
| 14607 | 54 H P—L, M | 59,000 | 94,000 | .00190 | 20.20 | 50.96 | 1⅛ inches from end of specimen | Accepted. | Also 55 and 56. |
| 14608 | 57 H P—L, M | 56,000 | 92,400 | .00177 | 21.50 | 50.96 | 1¼ inches from end of specimen | Accepted. | Also 58 and 59. |
| 14609 | 60 H P—L, M | 54,000 | 94,400 | .00170 | 22.53 | 53.83 | 1 inch from end of specimen | Accepted. | Also 61 and 62. |
| 14578 | 63 H P—L, M | 62,000 | 100,000 | .00207 | 20.90 | 54.12 | 1¼ inches from end of specimen | Accepted. | Also 64 and 65. |
| 14610 | 66 H P—L, M | 55,000 | 94,000 | .00167 | 22.20 | 53.40 | 1⅜ inches from end of specimen | Accepted. | Also 67 and 68. |
| 14598 | 69 H P—L, M | 56,000 | 92,800 | .00177 | 21.60 | 54.84 | 1⅜ inches from end of specimen | Accepted. | Also 70 and 71. |
| 14579 | 72 H P—L, M | 59,000 | 98,000 | .00197 | 19.00 | 50.20 | 1 inch from end of specimen | Accepted. | Also 73. |
| 14996 | 74 H P—L, M | 51,000 | 84,000 | .00157 | 23.20 | 58.84 | 1 inch from end of specimen | Accepted. | |
| | *Face plates.* | | | | | | | | |
| 13645 | 12 M R 31 F P—T, M | 51,000 | 90,400 | .00173 | 22.30 | 43.75 | 1⅜ inches from end of specimen | Accepted. | |
| 13676 | 32 F P—T, M | 48,000 | 90,400 | .00167 | 21.50 | 45.07 | 1⅜ inches from end of specimen | Accepted. | |
| 13680 | 33 F P—T, M | 56,000 | 96,800 | .00183 | 19.37 | 42.15 | 1¼ inches from end of specimen | Accepted. | |
| 13681 | 34 F P—T, M | 57,000 | 96,800 | .00200 | 20.00 | 43.22 | 1⅜ inches from end of specimen | Accepted. | |
| 13710 | 35 F P—T, M | 51,000 | 92,000 | .00160 | 23.20 | 47.15 | 1⅜ inches from end of specimen | Accepted. | |
| 13705 | 36 F P—T, M | 54,000 | 94,400 | .00173 | 19.67 | 42.42 | 1⅜ inches from end of specimen | Accepted. | |
| 13706 | 37 F P—T, M | 53,000 | 92,000 | .00170 | 18.47 | 32.02 | 1⅜ inches from end of specimen | Accepted. | |

*Tensile tests for 12-inch B. L. rifled mortars (cast-iron body, steel hooped)*—Continued.

TABLE XXI.—BREECH MECHANISM—Continued.

| Mid-vale No. | Marks on specimens. | Elastic limit per square inch of original section. | Ultimate strength per square inch of original section. | Elongation per inch under stress at elastic limit. | Ultimate elongation after rupture, per cent of original length. | Reduction in area after rupture, per cent of original section. | Position of rupture. | Remarks relative to acceptance, rejection, retreatment, etc. |
|---|---|---|---|---|---|---|---|---|
| | *Face plates*—Continued. | | | | | | | |
| | | *Pounds.* | *Pounds.* | | | | | |
| 13707 | 12 M R 38 F P—$T_1$ M | 56,000 | 95,200 | .00207 | 19.00 | 42.69 | 1 inch from end of specimen | Accepted. |
| 13708 | 39 F P—$T_1$ M | 50,000 | 92,000 | .00180 | 20.60 | 41.61 | 1¾ inches from end of specimen | Accepted. |
| 13709 | 40 F P—$T_1$ M | 55,000 | 98.400 | .00193 | 20.40 | 37.75 | ⅞ inch from end of specimen | Accepted. |
| 13736 | 41 F P—$T_1$ M | 50,000 | 93,200 | .00180 | 18.87 | 43.49 | ¾ inch from end of specimen | Accepted. |
| 13732 | 42 F P—$T_1$ M | 52,000 | 90,000 | .00167 | 18.47 | 32.02 | 1⅜ inches from end of specimen | Accepted. |
| 13729 | 43 F P—$T_1$ M | 53,000 | 92,000 | .00173 | 20.20 | 40.52 | 1⅜ inches from end of specimen | Accepted. |
| 13730 | 44 F P—$T_1$ M | 54,000 | 89,600 | .00187 | 6.98 | 11.70 | 1⅜ inches from end of specimen | Fractured through a blow hole. A second bar taken behind and parallel to this specimen. |
| 13779 | 44 F P—$T_1$ M | 56,000 | 93,200 | .00173 | 19.87 | 48.18 | 1⅜ inches from end of specimen | Accepted. |
| 13731 | 45 F P—$T_1$ M | 52,000 | 94,000 | .00167 | 18.93 | 39.69 | 1 inch from end of specimen | Accepted. |
| 13759 | 46 F P—$T_1$ M | 53,000 | 94,000 | .00177 | 14.00 | 19.83 | ⅝ inch from end of specimen | Accepted. |
| 13979 | 46 F P—$T_2$ M | 47,000 | 84,000 | .00157 | 22.70 | 48.70 | 1 inch from end of specimen | Fractured through a blow hole. A second bar taken behind and parallel to this specimen. |
| 13758 | 47 F P—$T_1$ M | 56,000 | 96,400 | .00200 | 21.00 | 42.95 | 1⅜ inches from end of specimen | Accepted. |
| 13733 | 48 F P—$T_1$ M | 52,000 | 90,200 | .00177 | 20.70 | 44.54 | 1⅝ inches from end of specimen | Accepted. |
| 13783 | 49 F P—$T_1$ M | 54,000 | 88,800 | .00167 | 21.67 | 48.94 | 1⅜ inches from end of specimen | Accepted. |
| 13799 | 50 F P—$T_1$ M | 59,000 | 89,200 | .00200 | 22.10 | 51.20 | 1 inch from end of specimen | Accepted. |
| 13800 | 51 F P—$T_1$ M | 56,000 | 88,000 | .00190 | 21.10 | 47.40 | 1½ inches from end of specimen | Accepted. |
| 13959 | 52 F P—$T_1$ M | 50,000 | 87,200 | .00153 | 23.00 | 48.44 | 1¼ inches from end of specimen | Accepted. |
| 13957 | 53 F P—$T_1$ M | 48,000 | 79,600 | .00143 | 26.29 | 56.03 | 1½ inches from end of specimen | Accepted. |
| 13958 | 54 F P—$T_1$ M | 46,000 | 79,200 | .00137 | 24.70 | 55.79 | 1 inch from end of specimen | Accepted. |
| 13987 | 55 F P—$T_1$ M | 50,000 | 83,600 | .00173 | 21.40 | 53.64 | 1 inch from end of specimen | Accepted. |
| 13976 | 56 F P—$T_1$ M | 48,000 | 81,600 | .00157 | 24.80 | 53.16 | 1½ inches from end of specimen | Accepted. |
| 13988 | 57 F P—$T_1$ M | 49,000 | 83,600 | .00153 | 23.73 | 51.45 | 1½ inches from end of specimen | Accepted. |
| 14002 | 58 F P—$T_1$ M | 46,000 | 80,400 | .00127 | 23.10 | 49.46 | ¾ inch from end of specimen | Accepted. |
| 14001 | 59 F P—$T_1$ M | 49,000 | 84,400 | .00160 | 23.20 | 52.65 | 1½ inches from end of specimen | Accepted. |
| 13998 | 60 F P—$T_1$ M | 51,000 | 85,200 | .00167 | 25.40 | 52.43 | 1½ inches from end of specimen | Accepted. |
| 13995 | 61 F P—$T_1$ M | 54,000 | 84,800 | .00170 | 22.60 | 51.45 | 1½ inches from end of specimen | Accepted. |
| 13991 | 62 F P—$T_1$ M | 53,000 | 84,800 | .00170 | 23.20 | 52.91 | 1¼ inches from end of specimen | Accepted. |
| 14000 | 63 F P—$T_1$ M | 46,000 | 84.800 | .00150 | 25.60 | 48.44 | 1½ inches from end of specimen | Accepted. |
| 14042 | 64 F P—$T_1$ M | 50,000 | 88,400 | .00173 | 24.30 | 50.70 | 1½ inches from end of specimen | Accepted. |
| 13996 | 65 F P—$T_1$ M | 47,000 | 81,000 | .00153 | 20.00 | 47.15 | ⅝ inch from end of specimen | Accepted. |
| 13992 | 66 F P—$T_1$ M | 48,000 | 85,200 | .00153 | 21.70 | 33.76 | 1½ inches from end of specimen | Accepted. |
| 13993 | 67 F P—$T_1$ M | 52,000 | 80,800 | .00163 | 22.60 | 43.75 | 1½ inches from end of specimen | Accepted. |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 13989 | | 68 F P—$T_1$ M | 48,000 | 80,400 | .00133 | 18.60 | 34.92 | 1¼ inches from end of specimen | Accepted. |
| 13097 | | 69 F P—$T_1$ M | 46,000 | 80,000 | .00133 | 23.20 | 55.79 | 1 inch from end of specimen | Accepted. |
| 13990 | | 70 F P—$T_1$ M | 46,000 | 80,000 | .00143 | 23.90 | 51.91 | 1 inch from end of specimen | Accepted. |
| 13999 | | 71 F P—$T_1$ M | 47,000 | 80,000 | .00147 | 23.80 | 50.70 | 1⅜ inches from end of specimen | Accepted. |
| 14997 | | 72 F P—$T_1$ M | 55,000 | 93,600 | .00193 | 20.80 | 45.07 | 1⅝ inches from end of specimen | Accepted. |
| 15002 | | 73 F P—$T_1$ M | 59,000 | 97,600 | .00200 | 21.00 | 48.18 | 1⅜ inches from end of specimen | Accepted. |
| | | *Spindles.* | | | | | | | |
| 13585 | 12 M R | 31 Sp—$T_1$ O | 55,000 | 95,600 | .00187 | 18.98 | 41.61 | ⅞ inch from end of specimen | Accepted. Also No. 40. |
| 13694 | | 31 Sp—$T_2$ M | 53,000 | 96,000 | .00197 | 18.27 | 30.55 | 1 inch from end of specimen | |
| 13695 | | 32 Sp—$T_1$ O | 55,000 | 97,200 | .00206 | 20.40 | 38.03 | 1⅜ inches from end of specimen | Accepted. Also No. 52. |
| 13846 | | 32 Sp—$T_2$ M | 53,000 | 96,400 | .00177 | 16.20 | 39.96 | 1¼ inches from end of specimen | |
| 13648 | | 33 Sp—$T_1$ O | 54,000 | 94,400 | .00197 | 18.40 | 36.91 | 1 inch from end of specimen | Accepted. Also No. 39. |
| 13693 | | 33 Sp—$T_2$ M | 52,000 | 94,000 | .00177 | 17.93 | 26.35 | 1⅛ inches from end of specimen | |
| 13675 | | 34 Sp—$T_1$ O | 54,000 | 93,400 | .00190 | 20.20 | 39.14 | 1⅛ inches from end of specimen | Accepted. Also No. 43. |
| 13735 | | 34 Sp—$T_2$ M | 53,000 | 94,400 | .00197 | 17.90 | 31.43 | 1⅜ inches from end of specimen | |
| 13734 | | 35 Sp—$T_1$ O | 52,000 | 95,200 | .00180 | 17.33 | 21.72 | 1¼ inches from end of specimen | Condemned for a defect (piping) developed in machining. No. 45 accepted on this test. |
| 13794 | | 35 Sp—$T_2$ M | 51,000 | 94,800 | .00173 | 18.47 | 26.66 | ⅞ inch from end of specimen | |
| 13711 | | 36 Sp—$T_1$ O | 53,000 | 96,000 | .00180 | 18.50 | 26.05 | ¾ inch from end of specimen | Accepted. Also No. 44. |
| 13764 | | 36 Sp—$T_2$ M | 51,000 | 94,000 | .00180 | 17.37 | 29.87 | 1 inch from end of specimen | |
| 13756 | | 37 Sp—$T_1$ O | 54,000 | 96,000 | .00193 | 20.10 | 35.78 | 1¼ inches from end of specimen | Accepted. No. 46, its mate, was condemned for a defect developed in machining. |
| 13795 | | 37 Sp—$T_2$ M | 53,000 | 96,400 | .00167 | 16.90 | 29.07 | 1¼ inches from end of specimen | |
| 13757 | | 38 Sp—$T_1$ O | 56,000 | 94,800 | .00173 | 20.00 | 42.42 | 1⅛ inches from end of specimen | Accepted. Also No. 47. |
| 13796 | | 38 Sp—$T_2$ M | 54,000 | 94,800 | .00200 | 19.03 | 32.36 | 1 inch from end of specimen | |
| 13797 | | 41 Sp—$T_1$ O | 51,000 | 92,000 | .00167 | 23.60 | 45.60 | 1½ inches from end of specimen | Accepted. Also No. 55. |
| 13895 | | 41 Sp—$T_2$ M | 51,000 | 92,200 | .00170 | 20.40 | 34.05 | 1 inch from end of specimen | |
| 13798 | | 42 Sp—$T_1$ O | 53,000 | 92,200 | .00173 | 19.53 | 28.17 | 1¼ inches from end of specimen | Accepted. Also No. 53. |
| 13847 | | 42 Sp—$T_2$ M | 49,000 | 92,200 | .00187 | 22.70 | 37.19 | ⅞ inch from end of specimen | |
| 13924 | | 48 Sp—$T_1$ O | 54,000 | 91,200 | .00183 | 20.50 | 38.86 | 1⅛ inches from end of specimen | Accepted. No. 61, its mate, was condemned for a defect developed in machining. |
| 13978 | | 48 Sp—$T_2$ M | 53,000 | 92,000 | .00173 | 18.10 | 31.73 | 1⅜ inches from end of specimen | |
| 13867 | | 49 Sp—$T_1$ O | 53,000 | 92,800 | .00167 | 20.80 | 36.91 | 1¼ inches from end of specimen | Accepted. Also No. 56. |
| 13953 | | 49 Sp—$T_2$ M | 51,000 | 91,600 | .00173 | 19.83 | 34.05 | 1 inch from end of specimen | |
| 13925 | | 50 Sp—$T_1$ O | 53,000 | 92,400 | .00173 | 20.60 | 42.42 | 1½ inches from end of specimen | Accepted. Also No. 57. |
| 13956 | | 50 Sp—$T_2$ M | 51,000 | 92,000 | .00163 | 20.20 | 31.14 | 1½ inches from end of specimen | |
| 13926 | | 51 Sp—$T_1$ O | 53,000 | 92,000 | .00170 | 19.20 | 32.90 | 1 inch from end of specimen | Accepted. Also No. 59. |
| 13975 | | 51 Sp—$T_2$ M | 52,000 | 91,600 | .00177 | 19.30 | 29,37 | 1¼ inches from end of specimen | |
| 13952 | | 54 Sp—$T_1$ O | 53,000 | 93,200 | .00183 | 17.00 | 28.47 | ¾ inch from end of specimen | Accepted. Also No. 62. |
| 14041 | | 54 Sp—$T_2$ M | 34,000 | 95,200 | .00173 | 17.20 | 29.66 | 1½ inches from end of specimen | |
| 14003 | | 58 Sp—$T_1$ O | 51,000 | 95,200 | .00163 | 16.60 | 31.43 | 1½ inches from end of specimen | Accepted. Also No. 64. |
| 14061 | | 58 Sp—$T_2$ M | 50,000 | 94,000 | .00190 | 16.93 | 26.35 | 1⅛ inches from end of specimen | |
| 14083 | | 63 Sp—$T_1$ O | 54,000 | 93,200 | .00177 | 19.50 | 36.63 | 1 inch from end of specimen | Accepted. Also No. 67. |
| 14129 | | 63 Sp—$T_2$ M | 53,000 | 94,400 | .00170 | 17.33 | 22.65 | 1⅜ inches from end of specimen | |
| 14146 | | 66 Sp—$T_1$ O | 51,000 | 89,200 | .00180 | 23.70 | 46.38 | 1½ inches from end of specimen | Accepted. |
| 14170 | | 66 Sp—$T_2$ M | 51,000 | 88,400 | .00160 | 20.20 | 28.77 | 1½ inches from end of specimen | |
| 15055 | | 60 Sp—$T_2$ O | 54,000 | 93,200 | .00177 | 21.40 | 39.14 | 1¾ inches from end of specimen | Accepted. Also No. 35 (new). |
| 15089 | | 60 Sp—$T_3$ M | 51,000 | 94,000 | .00173 | 19.57 | 37.19 | 1⅝ inches from end of specimen | |
| 15008 | | 68 Sp—$T_1$ O | 53,000 | 94,000 | .00170 | 20.80 | 49.20 | 1⅜ inches from end of specimen | Accepted. Also No. 72. |
| 15056 | | 68 Sp—$T_2$ M | 52,000 | 93,400 | .00173 | 19.47 | 42.95 | ⅞ inch from end of specimen | |

*Tensile tests for 12-inch B. L. rifled mortars (cast-iron body, steel hooped)*—Continued.

TABLE XXI.—BREECH MECHANISM—Continued.

| Midvale No. | Marks on specimens. | Elastic limit per square inch of original section. | Ultimate strength per square inch of original section. | Elongation per inch under stress at elastic limit. | Ultimate elongation after rupture, per cent of original length. | Reduction in area after rupture, per cent of original section. | Position of rupture. | Remarks relative to acceptance, rejection, retreatment, etc. |
|---|---|---|---|---|---|---|---|---|
| | *Spindles*—Continued. | *Pounds.* | *Pounds.* | | | | | |
| 15009 | 12 M R 69 Sp—T$_1$ O | 52,000 | 93,600 | .00160 | 19.37 | 36.91 | 1 inch from end of specimen | Accepted. Also No. 71. |
| 15046 | 69 Sp—T$_2$ M | 52,000 | 93,200 | .00167 | 18.00 | 32.90 | 1⅜ inches from end of specimen | |
| 15010 | 70 Sp—T$_1$ O | 55,000 | 98,000 | .00193 | 20.60 | 44.28 | 1¾ inches from end of specimen | Accepted. Also No. 73. |
| 15057 | 70 Sp—T$_2$ M | 53,000 | 98,000 | .00190 | 18.20 | 34.64 | 1⅜ inches from end of specimen | |

[Specimens 4 inches long between shoulders, diameter 0.565 inch, and 0.25 square inch cross section.]

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 16984 | 12 M R 74 Sp—T$_1$ O | 52,000 | 90,000 | .00163 | 23.50 | 51.94 | 1¼ inches from end of specimen | Accepted. Also No. 75. |
| 16992 | 74 Sp—T$_2$ M | 49,000 | 90,000 | .00157 | 19.60 | 37.75 | ⅞ inch from end of specimen | |
| 17058 | 76 Sp—T$_1$ O | 52,000 | 96,000 | .00170 | 20.00 | 42.15 | 1¼ inches from end of specimen | Accepted. |
| 17076 | 76 Sp—T$_2$ M | 50,000 | 96,400 | .00143 | 18 00 | 35.49 | 1 inch from end of specimen | |

[Specimens 3 inches long between shoulders, diameter 0.564 inches, and 0.25 square inch cross section.]

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | *Front gas-check cups.* | | | | | | | |
| 14672 | 12 M R 31 F G C—T$_1$ O | 85,000 | 139,600 | .00290 | 15.00 | 35.49 | 1 inch from end of specimen | Accepted. Also front gas-check cups Nos. 32, 33, and 34. |
| 14686 | 31 F G C—T$_2$ M | 75,000 | 131,600 | .00253 | 13.47 | 31.73 | 1 inch from end of specimen | |
| 14689 | 12 M R 40 F G C—T$_1$ O | 84,000 | 138,000 | .00260 | 14.80 | 33.48 | 1¼ inches from end of specimen | Accepted. Also front gas-check cups Nos. 35, 36, and 37. |
| 14705 | 40 F G C—T$_2$ M | 80,000 | 134,800 | .00263 | 14.90 | 32.32 | 1⅜ inches from end of specimen | |
| 14702 | 12 M R 45 F G C—T$_1$ O | 79,000 | 137,600 | .00263 | 15 13 | 35.21 | 1⅜ inches from end of specimen | Accepted. Also Nos. 38, 39, and 41. |
| 14743 | 45 F G C—T$_2$ M | 83,000 | 137,600 | .00270 | 15.60 | 38.58 | 1 inch from end of specimen | |
| 14941 | 12 M R 43 F G C—T$_1$ O | 74,000 | 130,400 | .00250 | 14.20 | 33.76 | 1⅝ inches from end of specimen | Accepted. Also Nos. 44, 46, and 47. |
| 14969 | 43 F G C—T$_2$ M | 72,000 | 130,400 | .00238 | 14.30 | 35.21 | ⅞ inch from end of specimen | |
| 15909 | 12 M R 51 F G C—T$_1$ O | 83,000 | 137,600 | .00243 | 14.30 | 33.19 | 1¼ inches from end of specimen | Accepted. Also Nos. 48, 49, and 50. |
| 15924 | 51 F G C—T$_2$ M | 79,000 | 137,600 | .00267 | 13.00 | 29.96 | ⅞ inch from end of specimen | |
| 15923 | 12 M R 55 F G C—T$_1$ O | 76,000 | 128,800 | .00227 | 13.80 | 37.19 | 1⅜ inches from end of specimen | Accepted. Also Nos. 52, 53, and 54. |
| 15941 | 55 F G C—T$_2$ M | 73,000 | 128,400 | .00220 | 15.90 | 34.34 | 1⅜ inches from end of specimen | |
| 16463 | 12 M R 42 F G C—T$_3$ M | 86,000 | 147,200 | .00300 | 12.87 | 29.07 | 1⅜ inches from end of specimen | Accepted. Also Nos. 56, 57, and 58. |
| 16428 | 42 F G C—T$_4$ O | 96,000 | 149,200 | 00277 | 12.40 | 28.47 | 1¼ inches from end of specimen | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | *Rear gas-check cups.* | | | | | | | |
| 14700 | 12 M R 31 R G C—$T_1$ O | 71,000 | 126,400 | .00238 | 14.80 | 35.78 | 1 inch from end of specimen | Accepted. Also rear gas-check cups Nos. 32, 33, and 34. |
| 14742 | 31 R G C—$T_2$ M | 74,000 | 126,400 | .00287 | 14.00 | 35.21 | 1¼ inches from end of specimen | |
| 14699 | 12 M R 36 R G C—$T_1$ O | 78,000 | 132,000 | .00257 | 10.00 | 12.86 | ⅞ inch from end of specimen | Accepted. Also rear gas-check cups Nos. 35, 37, and 38. |
| 14741 | 36 R G C—$T_2$ M | 76,000 | 126,000 | .00247 | 16.80 | 36.84 | 1⅛ inches from end of specimen | |
| 14701 | 12 M R 41 R G C—$T_1$ O | 76,000 | 132,000 | .00257 | 13.27 | 28.17 | 1¼ inches from end of specimen | Accepted. Also rear gas-check cups Nos. 39, 40, and 42. |
| 14743 | 41 R G C—$T_2$ M | 76,000 | 129,320 | .00258 | 14.60 | 31.43 | 1 inch from end of specimen | |
| 14916 | 12 M R 43 R G C—$T_1$ O | 78,000 | 133,200 | .00262 | 12.00 | 38.03 | 2 inches from end of specimen | Accepted. Also rear gas-check cups Nos. 45, 46, and 47. |
| 14943 | 43 R G C—$T_2$ M | 73,000 | 127,600 | .00237 | 15.50 | 33.19 | 1 inch from end of specimen | |
| 15008 | 12 M R 48 R G C—$T_1$ O | 78,000 | 126,400 | .00233 | 15.00 | 36.91 | 1⅛ inches from end of specimen | Accepted. Also rear gas-check cups Nos. 49, 50, and 51. |
| 15925 | 48 R G C—$T_2$ M | 70,000 | 125,400 | .00247 | 15.30 | 36.06 | 1¼ inches from end of specimen | |
| 15926 | 12 M R 52 R G C—$T_1$ O | 76,000 | 129,600 | .00260 | 14.00 | 34.92 | 1¼ inches from end of specimen | Accepted. Also rear gas-check cups Nos. 53, 54, and 55. |
| 15940 | 52 R G C—$T_2$ M | 72,000 | 125,720 | .00227 | 14.10 | 34.92 | 1 inch from end of specimen | |
| 16462 | 12 M R 44 R G C—$T_2$ O | 74,000 | 128,400 | .00247 | 13.98 | 36.34 | 1¾ inches from end of specimen | Accepted. Also rear gas-check cups Nos. 56, 57, and 58. |
| 16491 | 44 R G C—$T_3$ M | 71,000 | 125,200 | .00228 | 15.90 | 39.69 | 1⅝ inches from end of specimen | |
| | *Breechblocks.* | | | | | | | |
| 14814 | 12 M R 31 B B—$T_1$ O | 54,000 | 100,000 | .00200 | 17.60 | 29.96 | 1¼ inches from end of specimen | Accepted. Also No. 36. |
| 14828 | 31 B B—$T_2$ M | 51,000 | 100,000 | .00190 | 14.93 | 23.58 | ¾ inch from end of specimen | |
| 14815 | 12 M R 32 B B—$T_1$ O | 51,000 | 98,000 | .00167 | 18.00 | 32.61 | 1⅛ inches from end of specimen | Accepted. Also No. 34. |
| 14827 | 32 B B—$T_2$ M | 53,000 | 100,400 | .00200 | 16.33 | 24.51 | 1⅛ inches from end of specimen | |
| 15501 | 12 M R 35 B B—$T_2$ O | 54,000 | 98,000 | .00173 | 18.60 | 34.34 | 1⅜ inches from end of specimen | Accepted. Also No. 34. |
| 15515 | 35 B B—$T_3$ M | 52,000 | 98,000 | .00170 | 18.20 | 29.66 | 1⅝ inches from end of specimen | |
| 14829 | 12 M R 33 B B—$T_1$ O | 57,000 | 99,200 | .00193 | 19.67 | 39.14 | 1¾ inches from end of specimen | Not accepted on these tests. |
| 14841 | 33 B B—$T_2$ M | 56,000 | 101,200 | .00190 | 11.60 | 16.62 | ¾ inch from end of specimen | |
| 15528 | 33 B B—$T_3$ O | 56,000 | 97,600 | .00167 | 18.70 | 38.03 | 1 inch from end of specimen | Accepted. Also No. 39. |
| 15554 | 33 B B—$T_4$ M | 52,000 | 97,200 | .00173 | 16.47 | 33.48 | 1 inch from end of specimen | |
| 15605 | 12 M R 40 B B—$T_1$ O | 54,000 | 100,000 | .00183 | 18.10 | 34.34 | 1 inch from end of specimen | Accepted. Also No. 42. |
| 15618 | 40 B B—$T_2$ M | 53,000 | 98,000 | .00233 | 16.77 | 26.96 | 1 inch from end of specimen | |
| 15669 | 12 M R 37 B B—$T_2$ O | 50,000 | 94,800 | .00183 | 19.00 | 42.69 | 1⅛ inches from end of specimen | Accepted. Also No. 44. |
| 15648 | 37 B B—$T_3$ M | 47,000 | 90,800 | .00170 | 22.47 | 46.12 | 1⅛ inches from end of specimen | |
| 15625 | 12 M R 41 B B—$T_1$ O | 50,000 | 96,000 | .00200 | 19.90 | 34.05 | 1⅜ inches from end of specimen | Accepted. Also No. 43. |
| 15649 | 41 B B—$T_2$ M | 48,000 | 95,600 | .00173 | 16.73 | 32.32 | 1⅛ inches from end of specimen | |
| 16057 | 12 M R 45 B B $T_1$ O | 56,000 | 105,000 | .00180 | 15.33 | 28.77 | 1⅛ inches from end of specimen | Accepted. Also No. 47. |
| 16076 | 45 B B $T_2$ M | 54,000 | 104,800 | .00190 | 15.80 | 22.96 | 1⅜ inches from end of specimen | |
| 16492 | 12 M R 46 B B $T_2$ M | 50,000 | 95,200 | .00177 | 18.80 | 37.75 | 1⅛ inches from end of specimen | Accepted. Also No. 50. |
| 16445 | 46 B B $T_3$ O | 51,000 | 95,600 | .00173 | 20.30 | 42.69 | 1⅝ inches from end of specimen | |
| 16392 | 12 M R 48 B B $T_1$ O | 48,000 | 90,600 | .00167 | 21.50 | 44.54 | ¾ inch from end of specimen | Accepted. Also No. 49. |
| 16395 | 48 B B $T_2$ M | 46,000 | 88,000 | .00167 | 23.30 | 42.69 | 1⅛ inches from end of specimen | |
| 16900 | 12 M R 53 B B $T_1$ O | 58,000 | 94,400 | .00140 | 21.90 | 45.86 | 1¼ inches from end of specimen | Accepted. Also No. 51. |
| 16920 | 53 B B $T_2$ M | 52,000 | 95,000 | .00173 | 19.40 | 41.88 | 1 inch from end of specimen | |
| 16919 | 12 M R 54 B B—$T_1$ O | 52,000 | 95,200 | .00167 | 19.39 | 43.75 | 1⅛ inches from end of specimen | Accepted. Also No. 56. |
| 16983 | 54 B B—$T_2$ M | 50,000 | 92,000 | .00160 | 20.20 | 41.88 | 1¼ inches from end of specimen | |
| 16983 | 12 M R 55 B B—T O | 48,000 | 88,000 | .00173 | 22.00 | 46.64 | 1¼ inches from end of specimen | Accepted. Also No. 58. |
| 17028 | 55 B B—$T_2$ M | 47,000 | 90,400 | .00143 | 21.33 | 46.12 | 1 inch from end of specimen | |
| 16993 | 12 M R 57 B B—$T_1$ O | 47,000 | 88,000 | .00143 | 24.40 | 49.71 | 1⅝ inches from end of specimen | Accepted. Also No. 59. |
| 17029 | 57 B B—$T_2$ M | 46,000 | 90,000 | .00140 | 20.80 | 41.07 | ¾ inch from end of specimen | |

TABLE XXII.—*Hardness, specific gravity, and tensile tests; cylindrical hoops for 12-inch B. L. R. mortars (cast-iron body, steel hooped).*

[Specimens 4 inches long between shoulders, diameter 0.564 inch, and 0.25 square inch cross section Hardness and specific gravity specimens 1 inch long and 1 inch in diameter; cylindrical specimens. Contract of December 1, 1890.]

| Number of set. | Marks on specimens. | | Specific gravity. | Hardness. | Elastic limit per square inch of original section. | Ultimate strength per square inch of original section. | Ultimate elongation after rupture, per cent of original length. | Reduction in area after rupture, per cent of original section. | Remarks relative to acceptance, rejection, retreatment, etc. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Pounds* | *Pounds.* | | | |
| 31 | ........ | | ........ | ........ | ........ | ........ | ........ | ........ | Not taken. |
| 32 | 12 M R 32 $A_5$... | $T_1$ O | 7.8382 | 24.40 | 58,000 | 107,200 | 15.50 | 31.73 | Forged. |
| | | $T_2$ M | | | 60,000 | 107,200 | 18.10 | 38.86 | |
| | | $T_3$ I | | | 65,000 | 112,000 | 15.90 | 35.78 | |
| 33 | 12 M R 33 $A_5$... | $T_1$ O | 7.8388 | 22.26 | 60,000 | 107,600 | 12.00 | 17.59 | Forged. |
| | | $T_2$ M | | | 56,000 | 104,600 | 14.40 | 24.51 | |
| | | $T_3$ I | | | 60,000 | 108,000 | 14.45 | 26.05 | |
| 34 | 12 M R 34 $A_5$... | $T_1$ O | 7.8497 | 19.81 | 55,000 | 96,400 | 18.25 | 50.46 | Forged. |
| | | $T_4$ M | | | 52,000 | 92,000 | 19.80 | 51.70 | |
| | | $T_3$ I | | | 52,000 | 92,800 | 18.60 | 57.43 | |
| 35 | 12 M R 35 $A_5$... | $T_1$ O | 7.8396 | 21.05 | 53,000 | 97,400 | 19.10 | 41.34 | Forged. |
| | | $T_2$ M | | | 53,000 | 98,800 | 17.90 | 35.78 | |
| | | $T_3$ I | | | 54,000 | 96,400 | 20.30 | 45.34 | |
| 36 | 12 M R 36 $A_5$... | $T_1$ O | 7.8452 | 19.08 | 53,000 | 94,800 | 19.40 | 45.60 | Forged from a bored ingot. |
| | | $T_2$ M | | | 53,000 | 95,600 | 16.60 | 29.66 | |
| | | $T_3$ I | | | 52,000 | 95,600 | 12.10 | 28.47 | |
| 37 | 12 M R 37 $A_5$... | $T_1$ O | 7.8433 | 21.52 | 53,000 | 100,000 | 12.40 | 20.45 | Forged from a bored ingot. |
| | | $T_2$ M | | | 58,000 | 103,200 | 14.32 | 26.05 | |
| | | $T_3$ I | | | 59,000 | 101,600 | 13.10 | 19.83 | |
| 38 | 12 M R 38 $A_5$... | $T_1$ O | 7.8503 | 21.17 | 56,000 | 100,000 | 16.50 | 34.64 | Forged from a bored ingot. |
| | | $T_2$ M | | | 56,000 | 104,400 | 12.10 | 15.65 | |
| | | $T_3$ I | | | 57,000 | 104.800 | 14.80 | 32.02 | |
| 39 | 12 M R 39 $A_5$... | $T_1$ O | 7.8525 | 19.50 | 55,000 | 102,000 | 17.60 | 35.78 | Forged from a bored ingot. |
| | | $T_3$ M | | | 53,000 | 96,800 | 16.50 | 38.30 | |
| | | $T_3$ I | | | 57,000 | 97,600 | 17.30 | 42.95 | |
| 40 | 12 M R 40 $A_5$... | $T_1$ O | 7.8455 | 20.03 | 55,000 | 95,600 | 17.70 | 38.03 | Forged from a bored ingot. |
| | | $T_2$ M | | | 56,000 | 100,000 | 12.60 | 15.00 | |
| | | $T_3$ I | | | 56,000 | 98,000 | 9.80 | 14.67 | |
| | | $T_4$ I | | | 54,000 | 95,280 | 13.00 | 29.96 | |
| 41 | 12 M R 41 $B_4$... | $T_1$ O | 7.8408 | 21.77 | 59,000 | 104,000 | 16.40 | 41.07 | Rolled. |
| | | $T_2$ M | | | 60,000 | 104,000 | 15.10 | 37.75 | |
| | | $T_3$ I | | | 65,000 | 108,800 | 16.10 | 40.79 | |
| 42 | 12 M R 42 $B_1$... | $T_1$ O | 7.8385 | 20.14 | 55,000 | 101,200 | 19.30 | 42.15 | Rolled. |
| | | $T_2$ M | | | 52,000 | 98,800 | 14.80 | 25.13 | |
| | | $T_3$ I | | | 59,000 | 106,400 | 15.10 | 33.48 | |
| 43 | 12 M R 43 $B_1$... | $T_1$ O | 7.8435 | 24.54 | 64,000 | 112,000 | 16.80 | 36.34 | Rolled. |
| | | $T_4$ M | | | 59,000 | 111,200 | 13.85 | 32.32 | |
| | | $T_3$ I | | | 61,000 | 108,000 | 14.80 | 36.63 | |
| 44 | 12 M R 44 $B_4$... | $T_1$ O | ........ | ........ | 58,000 | 104,000 | 13.40 | 19.83 | Rolled. |
| | | $T_2$ M | | | 55,000 | 102,800 | 13.20 | 21.41 | |
| | | $T_3$ I | | | 61,000 | 108,000 | 16.90 | 39.96 | |
| 45 | 12 M R 45 $B_4$... | $T_1$ O | 7.8384 | 23.70 | 62,000 | 106,800 | 16.50 | 27.56 | Rolled. |
| | | $T_2$ M | | | 58.000 | 109,200 | 15.00 | 25.43 | |
| | | $T_3$ I | | | 64,000 | 110,800 | 13.30 | 34.05 | |
| 46 | 12 M R 46 $A_3$... | $T_1$ O | 7.8261 | 22.90 | 57,000 | 103,600 | 18.80 | 45.34 | Rolled. |
| | | $T_2$ M | | | 57,000 | 102,400 | 18.00 | 42.15 | |
| | | $T_3$ I | | | 61,000 | 105,200 | 17.60 | 43.75 | |
| 47 | 12 M R 47 $A_3$... | $T_1$ O | 7.8423 | 22.64 | 61.000 | 105,600 | 18.50 | 39.14 | Rolled. |
| | | $T_4$ M | | | 57.000 | 100,800 | 16.45 | 32.61 | |
| | | $T_3$ I | | | 62,000 | 101,600 | 16.50 | 48.18 | |
| 48 | 12 M R 48 $A_4$... | $T_1$ O | 7.8444 | 27.49 | 68,000 | 118,800 | 15.75 | 32.90 | Rolled. |
| | | $T_2$ M | | | 61,000 | 110,800 | 14.11 | 32.61 | |
| | | $T_3$ I | | | 62,000 | 111,200 | 14.10 | 33.48 | |
| 49 | 12 M R 49 $A_4$... | $T_1$ O | 7.8402 | 21.40 | 59,000 | 108,400 | 14.20 | 32.02 | Rolled. |
| | | $T_2$ M | | | 55,000 | 104,800 | 16.50 | 33.76 | |
| | | $T_3$ I | | | 56,000 | 100,000 | 17.90 | 44.02 | |
| 50 | 12 M R 50 $A_4$... | $T_1$ O | 7.8442 | 21.89 | 56,000 | 105,200 | 12.20 | 15.32 | Rolled. |
| | | $T_2$ M | | | 52,000 | 98,000 | 17.10 | 31.73 | |
| | | $T_3$ I | | | 53,000 | 97,200 | 19.30 | 44.54 | |
| 51 | 12 M R 51 $B_1$... | $T_1$ O | 7.8498 | 21.64 | 54,000 | 101,000 | 13.00 | 30.55 | Rolled. |
| | | $T_2$ M | | | 54,000 | 102,800 | 15.10 | 32.61 | |
| | | $T_3$ I | | | 53,000 | 101,200 | 16.50 | 34.34 | |
| 52 | 12 M R 52 $B_4$... | $T_1$ O | 7.8449 | 19.60 | 54,000 | 99,200 | 18.85 | 36.91 | Rolled. |
| | | T, M | | | 53,000 | 97,600 | 19.60 | 42.15 | |
| | | $T_3$ I | | | 54,000 | 96,400 | 19.00 | 47.66 | |

TABLE XXII.—*Hardness, specific gravity, and tensile tests; cylindrical hoops for 12-inch B. L. R. mortars (cast-iron body, steel hooped)*—Continued.

| Number of set. | Marks on specimens. | Specific gravity. | Hardness. | Elastic limit per square inch of original section. | Ultimate strength per square inch of original section. | Ultimate elongation after rupture per cent of original length. | Reduction in area after rupture, per cent of original section. | Remarks relative to acceptance, rejection, retreatment, etc. |
|---|---|---|---|---|---|---|---|---|
| | | | | *Pounds.* | *Pounds.* | | | |
| 53 | 12 M R 53 $B_4$... $T_1$ O | 7.8426 | 20.70 | 53,000 | 99,600 | 18.20 | 36.91 | Rolled. |
| | $T_2$ M | | | 54,000 | 102,400 | 18.50 | 35.49 | |
| | $T_3$ I | | | 59,000 | 102,000 | 18.10 | 42.42 | |
| 54 | 12 M R 54 $B_4$... $T_1$ O | 7.8391 | 21.89 | 59,000 | 102,800 | 16.00 | 29.96 | Rolled. |
| | $T_2$ M | | | 56,000 | 101,800 | 16.20 | 42.95 | |
| | $T_3$ I | | | 60,000 | 99,400 | 19.30 | 54.12 | |
| 55 | 12 M R 55 $B_1$... $T_1$ O | 7.8473 | 23.43 | 55,000 | 97,600 | 19.70 | 43.75 | Rolled. |
| | $T_2$ M | | | 57,000 | 100,000 | 20.30 | 47.07 | |
| | $T_3$ I | | | 65,000 | 102,000 | 17.80 | 49.46 | |
| 56 | 12 M R 56 $A_4$... $T_1$ O | 7.8394 | 22.90 | 60,000 | 103,200 | 18.70 | 43.49 | Rolled. |
| | $T_4$ M | | | 61,000 | 103,400 | 18.70 | 43.22 | |
| | $T_3$ I | | | 64,000 | 108,000 | 16.70 | 42.69 | |
| 57 | 12 M R 57 $A_4$... $T_1$ O | 7.8397 | 17.90 | 56,000 | 98,800 | 18.30 | 33.76 | Rolled. |
| | $T_2$ M | | | 55,000 | 96,400 | 18.20 | 42.69 | |
| | $T_3$ I | | | 53,000 | 96,000 | 18.50 | 42.95 | |
| 58 | 12 M R 58 $A_4$... $T_1$ O | 7.8485 | 22.64 | 55,000 | 102,400 | 15.30 | 55.21 | Rolled. |
| | $T_2$ M | | | 52,000 | 96,000 | 18.80 | 42.15 | |
| | $T_3$ I | | | 54,000 | 96,000 | 19.30 | 47.66 | |
| 59 | 12 M R 59 $A_4$... $T_1$ O | 7.8430 | 20.82 | 59.000 | 106,800 | 15.50 | 32.90 | Rolled. |
| | $T_2$ M | | | 52,000 | 97,600 | 16.85 | 38.30 | |
| | $T_3$ I | | | 54,000 | 96,800 | 15.60 | 43.22 | |
| 60 | 12 M R 60 $B_1$... $T_1$ O | 7.8462 | 19.92 | 53,000 | 95,200 | 20.50 | 44.28 | Rolled. |
| | $T_2$ M | | | 52,000 | 97,600 | 15.90 | 38.58 | |
| | $T_3$ I | | | 52,000 | 95,200 | 16.60 | 46.38 | |
| 61 | 12 M R 61 $A_3$... $T_1$ O | 7.8408 | 22.52 | 62,000 | 102,800 | 18.20 | 44.56 | Rolled. |
| | $T_2$ M | | | 57,000 | 102,800 | 18.65 | 40.52 | |
| | $T_3$ I | | | 59,000 | 100,800 | 19.40 | 47.66 | |
| 62 | 12 M R 62 $B_1$... $T_1$ O | 7.8412 | 18.58 | 59,000 | 101,600 | 17.10 | 38.58 | Rolled. |
| | $T_2$ M | | | 54,000 | 98,800 | 16.15 | 36.34 | |
| | $T_3$ I | | | 56,000 | 97,600 | 17.80 | 47.66 | |
| 63 | 12 M R 63 $B_1$... $T_1$ O | 7.8430 | 21.40 | 55,000 | 100,000 | 17.50 | 38.58 | Rolled. |
| | $T_2$ M | | | 52,000 | 99,200 | 16.65 | 34.92 | |
| | $T_3$ I | | | 54,000 | 95,200 | 20.20 | 50.96 | |
| 64 | 12 M R 64 $A_3$... $T_1$ O | 7.8468 | 21.89 | 57,000 | 98,800 | 18.60 | 44.54 | Rolled. |
| | $T_3$ M | | | 57,000 | 100,000 | 19.30 | 42.42 | |
| | $T_4$ I | | | 56,000 | 98,800 | 16.30 | 39.41 | |
| 65 | 12 M R 65 $B_1$... $T_1$ O | 7.8466 | 20.98 | 56,000 | 101,600 | 17.50 | 35.78 | Rolled. |
| | $T_2$ M | | | 54,000 | 100,000 | 15.80 | 38.58 | |
| | $T_3$ I | | | 54,000 | 96,000 | 17.40 | 43.75 | |

### TABLE XXIII.—*Midvale Steel Works.—Tensile tests for 3.6-inch B. L. R mortar.*

### CARRIAGE FRAMES AND ELEVATING ARCS.

[Specimens 2 inches long between shoulders and 0.505 square inch cross section; 20 square inch steel castings. Contract of June 8, 1891.]

| Midvale No. | Marks on specimens. | Elastic limit per square inch of original section. | Ultimate strength per square inch of original section. | Ultimate elongation at rupture. | Reduction in area after rupture, per cent of original section. | Position of rupture. | Character of broken surface, manner of failure, etc. | Remarks relative to acceptance, rejection, retreatment, etc. |
|---|---|---|---|---|---|---|---|---|
| | | *Pounds.* | *Pounds.* | *Per cent.* | | | | |
| 15981 | 3″.6 M R 1 C L, R ... | 32,000 | 60,000 | 20.20 | 59.00 | ⅛ inch from end ... | Silky ............ | Accepts carriage No. 1 and elevating arcs Nos. 3 and 4. |
| 16009 | 3″.6 M R 1 C L, L ... | 33,000 | 62,000 | 27.40 | 55.46 | ⅛ inch from end ... | Silky ............ | |
| 15998 | 3″.6 M R 2 C L, R ... | 27,500 | 59,000 | 31.10 | 57.81 | ⅛ inch from end ... | Silky ............ | Accepts carriage No. 1 and elevating arcs Nos. 1 and 2. |
| 16010 | 3″.6 M R 2 C L, L ... | 27,000 | 59,000 | 35.80 | 52.22 | 1⅜ inches from end. | Silky ............ | |
| 16207 | 3″.6 M R 3 C L, R ... | 37,000 | 64,000 | 22.30 | 30.50 | .................. | Silky ............ | Accepts carriage No. 3, condemned for holes, etc. |
| 16214 | 3″.6 M R 3 C L, L ... | 35,000 | 62,500 | 27.00 | 37.59 | ¾ inch from end ... | Silky ............ | |
| 16232 | 3″.6 M R 4 C L, R ... | 35,000 | 64,000 | 26.00 | 36.30 | ¼ inch from end ... | Silky ............ | Accepts carriage No. 4. |
| 16247 | 3″.6 M R 4 C L, L ... | 36,500 | 65,500 | 23.00 | 34.74 | ¼ inch from end ... | Silky ............ | |
| 16231 | 3″.6 M R 5 C L, R ... | 30,500 | 62,500 | 23.10 | 38.19 | ⅜ inch from end ... | Silky ............ | Accepts carriage No. 5 and elevating arcs Nos. 2, 5, and 6. |
| 16248 | 3″.6 M R 5 C L, L ... | 30,000 | 60,000 | 30.50 | 48.62 | ⅜ inch from end ... | Silky ............ | |
| 16267 | 3″.6 M R 6 C L, R ... | 30,000 | 62,000 | 21.00 | 44.33 | ⅜ inch from end ... | Silky ............ | Accepts carriage No. 6; condemned for cracks. |
| 16268 | 3″.6 M R 6 C L, L ... | 32,500 | 63,000 | 23.00 | 37.24 | 1 inch from end ... | Smoky ............ | |
| 16475 | 3″.6 M R 7 C L, R ... | 30,500 | 60,000 | 30.80 | 48.62 | .................. | Silky ............ | Accepts carriage No. 7 and elevating arcs Nos. —— |
| 16474 | 3″.6 M R 7 C L, L ... | 29,500 | 58,500 | 24.40 | 33.45 | .................. | Granular; 30 per cent silky. | |
| 16477 | 3″.6 M R 8 C L, R ... | 32,000 | 62,500 | 31.70 | 51.97 | .................. | Silky ............ | Accepts carriage No. 8. |
| 16476 | 3″.6 M R 8 C L, L ... | 34,000 | 61,000 | 14.20 | 27.51 | .................. | Silky ............ | |
| 16437 | 3″.6 M R 9 C L, L ... | 35,000 | 64,000 | 31.30 | 48.62 | ½ inch from end ... | Dark silky ........ | Accepts carriage No. 9. |
| 16436 | 3″.6 M R 9 C L, L ... | 34,500 | 63,000 | 24.20 | 39.44 | ½ inch from end ... | Dark smoky ........ | |
| 16532 | 3″.6 M R 10 C L, R .. | 36,000 | 64,500 | 25.00 | 34.09 | .................. | Silky ............ | Accepts carriage No. 10; elevating arcs Nos. 11, 12, 13, 14. |
| 16533 | 3″.6 M R 10 C L, L .. | 33,500 | 63,500 | 31.00 | 50.57 | .................. | Silky ............ | |
| 16754 | 3″.6 M R 11 C L, R .. | 28,000 | 58,250 | 22.50 | 30.15 | .................. | Granular .......... | Accepts carriage No. 11, condemned for holes, etc. |
| 16753 | 3″.6 M R 11 C L, L .. | 27,500 | 59,000 | 36.40 | 56.01 | .................. | Silky ............ | |
| 16741 | 3″.6 M R 12 C L, R .. | 28,500 | 57,500 | 29.50 | 56.51 | .................. | Silky ............ | Accepts carriage No. 12. |
| 16740 | 3″.6 M R 12 C L, L .. | (*) | 57,000 | 21.90 | 30.50 | .................. | Bright granular; small silky spot. | |
| 16756 | 3″.6 M R 13 C L, R .. | 28,500 | 58,000 | 26.30 | 49.47 | .................. | Silky ............ | Accepts carriage No. 13. |
| 16755 | 3″.6 M R 13 C L, L .. | 27,000 | 57,500 | 31.50 | 49.17 | .................. | Silky ............ | |
| 16758 | 3″.6 M R 14 C L, R .. | 25,000 | 57,500 | 31.20 | 41.28 | .................. | Granular .......... | Accepts carriage No. 14; elevating arc No. 15. |
| 16757 | 3″.6 M R 14 C L, L .. | 27,250 | 58,000 | 33.80 | 52.77 | .................. | Silky ............ | |
| 16943 | 3″.6 M R 15 C L, R .. | 28,000 | 60,000 | 32.50 | 57.06 | .................. | Silky ............ | Accepts carriage No. 15; condemned for holes, etc. |
| 16944 | 3″.6 M R 15 C L, L .. | 29,500 | 61,000 | 30.00 | 46.33 | .................. | Silky ............ | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 16945 | 3''.6 M R 16 C L, R.. | 35,000 | 63,500 | 25.50 | 41.80 | ........ | Silky ........ | Accepts carriage No. 16. |
| 16946 | 3''.6 M R 16 C L, L.. | 35,500 | 63,500 | 22.50 | 27.51 | ........ | Silky ........ | |
| 16947 | 3''.6 M R 17 C L, R.. | 32,000 | 63,000 | 26.50 | 49.47 | ........ | Silky ........ | Accepts carriage No. 17; elevating arcs Nos. 16, 17, 18, 19. |
| 16948 | 3''.6 M R 17 C L, L.. | 33,500 | 64,000 | 23.50 | 32.45 | ........ | Silky ........ | |
| | Grand means .... | 31,316 | 61,125 | 26.96<br>†27.51 | 43.73 | | | |
| | Maximum ........ | 37,000 | 65,500 | 36.40 | 59.00 | | | |
| | Minimum ........ | 27,000 | 57,000 | ‡14.20<br>20.20 | 27.61 | | | |
| | Maximum difference.. | 10,000 | 8,500 | †16.20 | 31.49 | | | |

* Not noticeable.

† Omitting abnormal specimen with 14.20 per cent elongation.

‡ Abnormal specimen; sand speck inside.

# APPENDIX 26.

## *PROGRESS REPORT ON THE MANUFACTURE OF STEEL FORGINGS, ETC., AT BETHLEHEM IRON WORKS, SOUTH BETHLEHEM, PA.*

OFFICE OF INSPECTOR OF ORDNANCE, U. S. ARMY,
BETHLEHEM IRON WORKS,
*South Bethlehem, Pa., September 1, 1891.*

SIR: Complying with your instructions, I have the honor to submit the following report showing the nature and progress of the work done for the Ordnance Department by the Bethlehem Iron Company during the fiscal year ending June 30, 1891.*

During the time specified the company continued work under the following contracts or orders, viz:

(1) Forgings for twenty-three 8-inch, twenty-three 10-inch, and fifteen 12-inch B. L. rifles.
(2) Forgings for 3.2-inch B. L. rifles (Driggs-Schroeder breech mechanism).
(3) Forgings for one 12-inch B. L. mortar (steel).
(4) Four forged-steel armored-deck plates.
(5) Forgings for ten 5-inch B. L. siege rifles.
(6) Twenty-four experimental steel shell for 12-inch B. L. mortar.

And also undertook to execute the following contracts or orders, viz:

(7) Twelve steel bolts and nuts for erection of armored-deck plates.
(8) Twenty-four finished steel rollers for 12-inch B. L. mortar carriage.
(9) One steel disk for chamber gauge for 12-inch B. L. mortar.
(10) Twelve securing-pins and screws for 8-inch and 10-inch B. L. rifles.
(11) Forgings for 3.2-inch B. L. rifles (Gordon breech mechanism).
(12) Twelve steel bolts and nuts for erection of armored-deck plates.
(13) Four steel armor plates for ballistic test of armor-piercing shot, fifty bolts and nuts, and 100 washers.
(14) Eight side plates for erection of armor plates.
(15) Sixty-three securing-pins and three locking rings for 8-inch, 10-inch, and 12-inch B. L. rifles.
(16) Two forged-steel armored-deck plates.
(17) Twelve bolts and nuts for erection of armored-deck plates.
(18) Jacket casting for 10-inch wire-wound B. L. rifle (Crozier).
(19) Forgings for sixteen 3.6-inch field B. L. mortars.
(20) Forgings for 8-inch Haskell multicharge gun.

At this date the orders numbered 2, 3, 4, 7, 8, 9, 10, 11, 12, 15, 16, and 17 are completed; those numbered 1, 5, 6, 13, 14, 18, 19, and 20 are still in hand.

The quality of the material furnished has been excellent, as will be seen from the results of tests given in detail in this report. The requirements of the specifications have been fully met, and it is specially to be noted that the qualities which were considered by manufacturers so late as two years ago very high and extremely difficult to meet are now obtained with comparatively little difficulty, requiring only that care and attention which should be given to such high-class and high-priced work. As an example of the quality of the material it may be stated that it is the exception when tube forgings for seacoast cannon do not show fully or very nearly the qualities which the specifications state are desired and the manufacturers shall aim to obtain; while for jacket forgings, though the desired qualities are not so frequently fully obtained, they are very nearly so in a large majority of cases. So far as the manufacture has progressed, there seems to be no more difficulty in obtaining the qualities in forgings of large caliber than in those of smaller caliber. The manufacture of hoop forgings of standard quality continues without incident and with certainty of product.

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* Under paragraph 22, part I, of the specifications, which states that "details of the operations carried on at the works will be considered confidential so far as the manufacturers may desire," the Bethlehem Iron Company desire that *all* details be considered confidential and for the use of the Department only; hence, all information relative to manufacture is omitted in this report.

The quantity of material delivered during the year was—

2 sets of 3.2-inch gun forgings;
7 sets of 5-inch gun forgings and parts of 3 other sets;
20 sets of 8-inch gun forgings;
2 sets of 10-inch gun forgings and parts of 2 other sets;
1 set of 12-inch gun forgings and part of 1 other set; and
1 set of 12-inch mortar forgings;

Together with a number of deck plates, bolts and nuts, mortar shells, and other forgings of miscellaneous character, or a total of about 620 tons of material.

The progress during the year on work for the Department has been on the whole quite satisfactory; there have been some delays in deliveries, due either to causes connected with the establishment and organization of an extensive plant or to the usual causes incident to all manufacturing establishments, but so far as known no interest of the Department has suffered by any of the delays which have occurred. In most cases where demands have been made for the hurried production of small orders or any special piece, the work has been done promptly and with evident endeavor to meet the desires of the Department.

For the coming year there is every reason to anticipate the delivery of all the material required by existing contracts.

A statement of the condition of the work under the several contracts or orders follows:

### *Forgings for 8-inch, 10-inch, and 12-inch B. L. rifles.*

Manufacture under this contract has continued without interruption during the year and the 8-inch forgings, excepting a few pieces, have been delivered. Twelve sets of these forgings have been shipped to Watervliet Arsenal and eleven sets to Cold Spring for finishing and assembling; the 10-inch and 12-inch forgings have been taken in hand during the year and delivery of the first set of each caliber was made within the shortest time contemplated by the contract. The further manufacture is in quite satisfactory condition.

The results of test of specimens, from forgings which have been accepted as to physical qualities during the year, were as follows:

*Results of tensile tests of tangential specimens from ends of tubes for 8-inch, 10-inch, and 12-inch B. L. rifles.*

[Length of specimen, 3 inches; sectional area, 0.25 square inch.]

| Caliber. | Number of tube. | Breech or muzzle. | Number of specimen. | Position of specimen. | Elastic limit per square inch of original section. | Elongation per inch under strain at elastic limit. | Tensile strength per square inch of original section. | Elongation after rupture. | Reduction in area after rupture. | Specific gravity. | Hardness. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Pounds.* | *Inch.* | *Pounds.* | *Per ct.* | *Per ct.* | | |
| 8 | *2 | Muzzle | 1 | Inside | 42,000 | .004950 | 78,400 | 26.00 | 54.64 | ........ | ........ |
| 8 | *2 | do | 2 | Outside | 40,000 | .001350 | 80,400 | 23.50 | 53.43 | ........ | ........ |
| 8 | *2 | do | 3 | Middle | —40,000 | ........ | 78,800 | 22.67 | 48.47 | ........ | ........ |
| 8 | *2 | Breech | 1 | Inside | 42,000 | .001500 | 91,600 | 18.83 | 31.19 | ........ | ........ |
| 8 | *2 | do | 2 | Outside | 44,000 | .001617 | 92,800 | 20.00 | 40.55 | ........ | ........ |
| 8 | *2 | do | 3 | Middle | 43,000 | .001550 | 92,000 | 18.67 | 38.62 | ........ | ........ |
| 8 | *2 | Muzzle | 4 | Inside | —35,000 | ........ | 74,800 | 27.00 | 53.92 | ........ | ........ |
| 8 | *2 | do | 5 | Middle | —40,000 | ........ | 75,200 | 28.00 | 54.40 | ........ | ........ |
| 8 | *2 | do | 6 | Outside | 40,000 | ........ | 76,800 | 25.83 | 51.48 | ........ | ........ |
| 8 | *2 | Breech | 4 | Inside | 47,000 | .001817 | 94,000 | 16.33 | 35.82 | ........ | ........ |
| 8 | *2 | do | 5 | Outside | 48,000 | .001733 | 93,200 | 18.67 | 43.52 | ........ | ........ |
| 8 | *2 | do | 6 | Middle | 46,000 | .001667 | 94,800 | 16.33 | 30,01 | ........ | ........ |
| 8 | 2 | Muzzle | 7 | Inside | —42,000 | ........ | 83,200 | 22.17 | 47.45 | ........ | ........ |
| 8 | 2 | do | 8 | Outside | 42,000 | .001500 | 85,600 | 20.67 | 46.67 | ........ | ........ |
| 8 | 2 | do | 9 | Middle | 44,000 | .001400 | 83,920 | 21.00 | 49.70 | ........ | ........ |
| 8 | 2 | Breech | 7 | Outside | 45,000 | .001683 | 92,400 | 19.33 | 43.52 | ........ | ........ |
| 8 | 2 | do | 8 | Inside | 42,000 | .001517 | 91,200 | 18.17 | 32.07 | ........ | ........ |
| 8 | 2 | do | 9 | Middle | 44,000 | .001533 | 94,120 | 17.70 | 36.40 | 7.8584 | 17.53 |
| 8 | *6 | Muzzle | 1 | Outside | 42,000 | ........ | 92,800 | 18.67 | 32.94 | ........ | ........ |
| 8 | *6 | do | 2 | Inside | 46,000 | ........ | 94,800 | 11.17 | 20.20 | ........ | ........ |
| 8 | *6 | do | 3 | Middle | 42,000 | ........ | 90,400 | 19.00 | 31.78 | ........ | ........ |
| 8 | *6 | Breech | 1 | do | —40,000 | ........ | 79,600 | 19.00 | 36.94 | ........ | ........ |
| 8 | *6 | do | 2 | Outside | 43,000 | ........ | 80,800 | 23.33 | 43.79 | ........ | ........ |
| 8 | *6 | do | 3 | Inside | —40,000 | ........ | 78,000 | 23.83 | 29.12 | ........ | ........ |
| 8 | *6 | Muzzle | 4 | do | 45,000 | ........ | 86,000 | 16.67 | 41.91 | ........ | ........ |
| 8 | *6 | do | 5 | Middle | 46,000 | ........ | 83,600 | 20.00 | 30.60 | ........ | ........ |
| 8 | *6 | do | 6 | Outside | 46,000 | ........ | 82,800 | 22.00 | 39.73 | ........ | ........ |
| 8 | *6 | Breech | 4 | do | 46,000 | ........ | 90,000 | 18.00 | 28.82 | ........ | ........ |
| 8 | *6 | do | 5 | Middle | —42,000 | ........ | 84,800 | 15.03 | 23.95 | ........ | ........ |
| 8 | *6 | do | 6 | Inside | —42,000 | ........ | 82,800 | 19.50 | 39.18 | ........ | ........ |
| 8 | †6 | Muzzle | 7 | Outside | 46,000 | .001600 | 85,200 | 23.00 | 41.37 | ........ | ........ |
| 8 | †6 | do | 8 | Inside | 47,000 | .001650 | 89,600 | 18.33 | 33.52 | ........ | ........ |
| 8 | †6 | do | 9 | Middle | 47,000 | .001650 | 87,600 | 17.00 | 21.77 | ........ | ........ |
| 8 | 6 | Breech | 7 | Outside | 46,000 | .001600 | 93,600 | 19.17 | 42.72 | ........ | ........ |
| 8 | 6 | do | 8 | Inside | 43,000 | .001550 | 90,400 | 19.33 | 31.19 | ........ | ........ |
| 8 | 6 | do | 9 | Middle | 42,000 | .001450 | 92,000 | 16.17 | 36.38 | ........ | ........ |
| 8 | 6 | Muzzle | 10 | Outside | 42,000 | .001617 | 80,800 | 26.50 | 42.72 | ........ | ........ |
| 8 | 6 | do | 11 | Inside | 47,000 | .001817 | 85,600 | 22.00 | 44.05 | ........ | ........ |
| 8 | 6 | do | 12 | Middle | 44,000 | .001633 | 83,200 | 19.83 | 22.71 | ........ | ........ |
| 8 | ‡9 | do | 1 | Outside | 42,000 | ........ | 92,000 | 15.17 | 24.88 | ........ | ........ |
| 8 | ‡9 | do | 2 | Middle | 50,000 | ........ | 90,800 | 16.17 | 23.95 | ........ | ........ |
| 8 | ‡9 | do | 3 | Inside | 49,000 | ........ | 92,400 | 20.67 | 23.95 | ........ | ........ |
| 8 | ‡9 | Breech | 1 | Outside | 52,000 | ........ | 100,000 | 18.33 | 38.62 | ........ | ........ |
| 8 | ‡9 | do | 2 | Inside | 52,000 | ........ | 103,600 | 14.00 | 15.32 | ........ | ........ |
| 8 | ‡9 | do | 3 | Middle | 47,000 | ........ | 96,800 | 17.83 | 33.81 | ........ | ........ |
| 8 | 9 | Muzzle | 4 | Outside | 45,000 | .001417 | 89,600 | 19.67 | 36.67 | ........ | ........ |
| 8 | 9 | do | 5 | Middle | 44,000 | .001600 | 83,200 | 22.83 | 43.25 | ........ | ........ |
| 8 | 9 | do | 6 | Inside | 45,000 | .001600 | 86,000 | 21.67 | 34.96 | ........ | ........ |
| 8 | 9 | Breech | 4 | Outside | 51,000 | .0018500 | 95,200 | 19.00 | 47.45 | ........ | ........ |
| 8 | 9 | do | 5 | Middle | 44,000 | .001533 | 90,000 | 21.83 | 42.45 | 7.8561 | 18.36 |
| 8 | 9 | do | 6 | Inside | 45,000 | .001567 | 90,400 | 19.50 | 33.81 | ........ | ........ |
| 8 | *11 | Muzzle | 1 | Middle | 46,000 | ........ | 90,000 | 22.17 | 52.71 | ........ | ........ |
| 8 | *11 | do | 2 | Outside | 47,000 | ........ | 89,200 | 20.50 | 36.10 | ........ | ........ |
| 8 | *11 | do | 3 | do | 47,000 | ........ | 86,400 | 21.00 | 49.99 | ........ | ........ |
| 8 | *11 | do | 4 | Middle | 50,000 | ........ | 85,960 | 25.30 | 47.20 | ........ | ........ |
| 8 | *11 | do | 5 | Inside | 49,000 | ........ | 89,440 | 20.00 | 44.60 | ........ | ........ |
| 8 | *11 | do | 6 | do | 47,000 | ........ | 87,600 | 19.00 | 44.58 | ........ | ........ |
| 8 | *11 | Breech | 1 | Outside | 46,000 | ........ | 90,800 | 15.67 | 31.78 | ........ | ........ |
| 8 | *11 | do | 2 | Middle | 46,000 | ........ | 89,080 | 16.00 | 24.60 | ........ | ........ |
| 8 | *11 | do | 3 | Inside | 44,000 | ........ | 89,200 | 17.33 | 39.45 | ........ | ........ |
| 8 | 11 | Muzzle | 7 | Middle | 44,000 | .001533 | 88,000 | 23.33 | 49.99 | ........ | ........ |
| 8 | 11 | do | 8 | Outside | 48,000 | .001633 | 90,560 | 16.00 | 24.60 | ........ | ........ |

* Not accepted on these results; retempered and annealed.
† Not accepted on these results; retested.
‡ Not accepted on these results; reannealed.

*Results of tensile tests of tangential specimens from ends of tubes for 8-inch, 10-inch, and 12-inch B. L. rifles*—Continued.

| Caliber. | Number of tube. | Breech or muzzle. | Number of specimen. | Position of specimen. | Elastic limit per square inch of original section. | Elongation per inch under strain at elastic limit. | Tensile strength per square inch of original section. | Elongation after rupture. | Reduction in area after rupture. | Specific gravity. | Hardness. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Pounds.* | *Inch.* | *Pounds.* | *Per ct.* | *Per ct.* | | |
| 8 | 11 | Muzzle.. | 9 | Inside ... | 52,000 | .001750 | 94,000 | 20.00 | 52.46 | ........ | ........ |
| 8 | 11 | ....do.... | 10 | Outside.. | 47,000 | .001600 | 87,600 | 21.33 | 47.70 | ........ | ........ |
| 8 | 11 | ....do.... | 11 | Inside ... | 43,000 | .001483 | 88,800 | 23.00 | 44.05 | ........ | ........ |
| 8 | 11 | ....do.... | 12 | Middle .. | 47,000 | .001633 | 87,360 | 20.70 | 33.50 | ........ | ........ |
| 8 | 11 | Breech .. | 4 | ....do .... | 46,000 | .001600 | 87,720 | 16.70 | 27.60 | 7.8552 | 16.90 |
| 8 | 11 | ....do.... | 5 | Outside.. | 45,000 | .001550 | 86,400 | 21.33 | 41.64 | ........ | ........ |
| 8 | 11 | ....do.... | 6 | Inside ... | 44,000 | .001600 | 88,800 | 17.17 | 35.53 | ........ | ........ |
| 8 | 12 | Muzzle.. | 1 | Outside.. | 50,000 | .001667 | 92,000 | 19.50 | 43.25 | ........ | ........ |
| 8 | 12 | ....do.... | 2 | Inside ... | 45,000 | .001533 | 90,800 | 21.67 | 42.99 | ........ | ........ |
| 8 | 12 | ....do.... | 3 | Middle .. | 45,000 | .001533 | 87,600 | 19.33 | 27.01 | ........ | ........ |
| 8 | 12 | Breech .. | 1 | Outside.. | 48,000 | .001717 | 92,400 | 17.83 | 28.52 | ........ | ........ |
| 8 | 12 | ....do.... | 2 | Middle .. | 42,000 | .001417 | 90,800 | 17.83 | 39.73 | 7.8520 | 17.17 |
| 8 | 12 | ....do.... | 3 | Inside ... | 45,000 | .001633 | 92,400 | 18.50 | 41.64 | ........ | ........ |
| 8 | *13 | Muzzle.. | 1 | Outside.. | 49,000 | .......... | 90,000 | 22.00 | 49.23 | ........ | ........ |
| 8 | *13 | ....do.... | 2 | Middle .. | 55,000 | .......... | 90,760 | 20.30 | 41.90 | ........ | ........ |
| 8 | *13 | ....do.... | 3 | Inside ... | 50,000 | .......... | 89,600 | 22.00 | 46.67 | ........ | ........ |
| 8 | *13 | ....do.... | 4 | Middle .. | 51,000 | .......... | 86,760 | 22.30 | 41.90 | ........ | ........ |
| 8 | *13 | ....do.... | 5 | Inside ... | 50,000 | .......... | 89,600 | 20.00 | 47.70 | ........ | ........ |
| 8 | *13 | ....do.... | 6 | Outside.. | 51,000 | .......... | 89,200 | 22.00 | 37.51 | ........ | ........ |
| 8 | *13 | Breech .. | 1 | ....do .... | 50,000 | .......... | 97,200 | 12.33 | 24.39 | ........ | ........ |
| 8 | *13 | ....do.... | 2 | Inside ... | 51,000 | .......... | 96,800 | 15.33 | 27.92 | ........ | ........ |
| 8 | *13 | ....do.... | 3 | Middle .. | 49,000 | .......... | 94,240 | 17.33 | 33.50 | ........ | ........ |
| 8 | 13 | Muzzle.. | 7 | Outside.. | 49,000 | .001783 | 86,800 | 23.00 | 50.73 | ........ | ........ |
| 8 | 13 | ....do.... | 8 | Inside ... | 50,000 | .001667 | 84,840 | 26.30 | 52.20 | ........ | ........ |
| 8 | 13 | ....do.... | 9 | Middle .. | 47,000 | .001617 | 84,000 | 22.00 | 43.79 | ........ | ........ |
| 8 | 13 | ....do.... | 10 | Inside ... | 47,000 | .001700 | 83,600 | 25.67 | 52.71 | ........ | ........ |
| 8 | 13 | ....do.... | 11 | Middle .. | 50,000 | .001700 | 82,880 | 26.30 | 52.20 | ........ | ........ |
| 8 | 13 | ....do.... | 12 | Outside.. | 48,000 | .001667 | 85,200 | 25.67 | 50.24 | ........ | ........ |
| 8 | 13 | Breech .. | 4 | ....do .... | 48,000 | .001717 | 91,600 | 21.00 | 44.58 | ........ | ........ |
| 8 | 13 | ....do.... | 5 | Middle .. | 45,000 | .001533 | 90,360 | 19.79 | 41.90 | 7.8516 | 17.99 |
| 8 | 13 | ....do.... | 6 | Inside ... | 44,000 | .001483 | 90,000 | 20.00 | 43.79 | ........ | ........ |
| 8 | 14 | Muzzle.. | 1 | Middle .. | 50,000 | .......... | 94,800 | 20.33 | 35.82 | ........ | ........ |
| 8 | 14 | ....do.... | 2 | Outside.. | 48,000 | .......... | 95,200 | 19.17 | 43.79 | ........ | ........ |
| 8 | 14 | ....do.... | 3 | Inside ... | 48,000 | .......... | 94,000 | 18.67 | 30.60 | ........ | ........ |
| 8 | †14 | Breech .. | 1 | Outside.. | 52,000 | .......... | 98,400 | 19.83 | 38.90 | ........ | ........ |
| 8 | †14 | ....do.... | 2 | Middle .. | 44,000 | .......... | 90,400 | 18.83 | 30.31 | ........ | ........ |
| 8 | †14 | ....do.... | 3 | Inside ... | 47,000 | .......... | 93,200 | 17.00 | 18.05 | ........ | ........ |
| 8 | ‡14 | ....do.... | 4 | Middle .. | 44,000 | .......... | 88,400 | 18.83 | 33.52 | ........ | ........ |
| 8 | ‡14 | ....do.... | 5 | Outside.. | 50,000 | .......... | 90,800 | 20.33 | 43.52 | ........ | ........ |
| 8 | ‡14 | ....do.... | 6 | Inside ... | 47,000 | .......... | 93,200 | 17.00 | 18.05 | ........ | ........ |
| 8 | 14 | Muzzle.. | 4 | ....do .... | 48,000 | .001667 | 95,600 | 17.33 | 26.41 | ........ | ........ |
| 8 | 14 | ....do.... | 5 | Outside.. | 51,000 | .001767 | 92,800 | 21.17 | 42.77 | ........ | ........ |
| 8 | 14 | ....do.... | 6 | Middle .. | 47,000 | 001650 | 92,400 | 20.50 | 42.45 | ........ | ........ |
| 8 | 14 | Breech .. | 7 | ....do .... | 42,000 | .001517 | 84,800 | 23.67 | 32.07 | 7.8546 | 15.51 |
| 8 | 14 | ....do.... | 8 | Outside.. | 42,000 | .001483 | 87,200 | 21.67 | 38.35 | ........ | ........ |
| 8 | 14 | ....do.... | 9 | Inside ... | 42,000 | .001517 | 88,000 | 21.33 | 28.52 | ........ | ........ |
| 8 | 15 | Muzzle.. | 1 | Middle .. | 51,000 | .001767 | 96,000 | 18.83 | 39.45 | ........ | ........ |
| 8 | 15 | ....do.... | 2 | ....do .... | 51,000 | .001817 | 94,000 | 20.17 | 46.93 | ........ | ........ |
| 8 | 15 | ....do.... | 3 | Inside ... | 49,000 | .001733 | 94,400 | 20.00 | 44.58 | ........ | ........ |
| 8 | 15 | Breech .. | 1 | Outside.. | 47,000 | .001633 | 93,600 | 18.83 | 41.91 | ........ | ........ |
| 8 | 15 | ....do.... | 2 | Middle .. | 43,000 | .001500 | 88,000 | 21.33 | 48.72 | 7.8592 | 17.62 |
| 8 | 15 | ....do.... | 3 | Inside ... | 43,000 | .001533 | 89,600 | 21.33 | 45.63 | ........ | ........ |
| 8 | 16 | Muzzle.. | 1 | Outside.. | 51,000 | .001800 | 94,000 | 20.50 | 47.97 | ........ | ........ |
| 8 | 16 | ....do.... | 2 | Middle... | 52,000 | .001767 | 93,600 | 19.83 | 47.19 | ........ | ........ |
| 8 | 16 | ....do.... | 3 | Inside ... | 50,000 | .001717 | 95,200 | 18.00 | 39.45 | ........ | ........ |
| 8 | 16 | Breech .. | 1 | Outside.. | 49,000 | .001700 | 96,800 | 18.83 | 39.18 | ........ | ........ |
| 8 | 16 | ....do.... | 2 | Inside ... | 47,000 | .001617 | 95,200 | 18.33 | 34.68 | ........ | ........ |
| 8 | 16 | ....do.... | 3 | Middle... | 47,000 | .001717 | 95,200 | 17.50 | 31.49 | 7.8588 | 18.98 |
| 8 | 17 | Muzzle.. | 1 | ....do .... | 49,000 | .001933 | 93,680 | 20.30 | 47.20 | ........ | ........ |
| 8 | 17 | ....do.... | 2 | Inside ... | 50,000 | .001767 | 96,800 | 18.33 | 44.05 | ........ | ........ |
| 8 | 17 | ....do.... | 3 | Outside.. | 49,000 | .001800 | 93,200 | 21.67 | 42.72 | ........ | ........ |
| 8 | 17 | Breech .. | 1 | Middle... | 49,000 | .001733 | 91,440 | 20.70 | 39.20 | 7.8534 | 18.29 |
| 8 | 17 | ....do.... | 2 | Inside ... | 47,000 | .001667 | 93,200 | 22.17 | 38.07 | ........ | ........ |
| 8 | 17 | ....do.... | 3 | Outside.. | 49,000 | .001750 | 95,200 | 20.33 | 44.85 | ........ | ........ |
| 8 | 18 | Muzzle.. | 1 | Inside ... | 44,000 | .001517 | 80,800 | 29.67 | 48.22 | ........ | ........ |
| 8 | 18 | ....do.... | 2 | Middle... | 44,000 | .001567 | 83,200 | 24.33 | 48.47 | ........ | ........ |
| 8 | 18 | ....do.... | 3 | Outside.. | 47,000 | .001650 | 85,200 | 24.00 | 45.37 | ........ | ........ |
| 8 | 18 | Breech .. | 1 | ....do .... | 50,000 | .001817 | 94,800 | 20.00 | 43.25 | ........ | ........ |
| 8 | 18 | ....do.... | 2 | Middle... | 45,000 | .001600 | 90,400 | 21.83 | 44.85 | 7.8629 | 18.19 |
| 8 | 18 | ....do.... | 3 | Inside ... | 46,000 | .001567 | 92,800 | 22.67 | 44.32 | ........ | ........ |

* Not accepted on these results; reannealed.

† Not accepted on these results; retested.

‡ Not accepted on these results; retempered and annealed.

*Results of tensile tests of tangential specimens from ends of tubes for 8-inch, 10-inch, and 12-inch B. L. rifles*—Continued.

| Caliber. | Number of tube. | Breech or muzzle. | Number of specimen. | Position of specimen. | Elastic limit per square inch of original section. | Elongation per inch under strain at elastic limit. | Testile strength per square inch of original section. | Elongation after rupture. | Reduction in area after rupture. | Specific gravity. | Hardness. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Pounds.* | *Inch.* | *Pounds.* | *Per ct.* | *Per ct.* | | |
| 8 | 19 | Muzzle.. | 1 | Middle... | 52,000 | .001767 | 94,800 | 19.17 | 41.91 | ........ | ........ |
| 8 | 19 | ....do.... | 2 | Inside ... | 48,000 | .001717 | 92,400 | 22.67 | 47.19 | ........ | ........ |
| 8 | 19 | ....do.... | 3 | Middle... | 49,000 | .001683 | 91,200 | 19.33 | 40.83 | ........ | ........ |
| 8 | 19 | Breech .. | 1 | Outside.. | 50,000 | .001717 | 94,400 | 21.50 | 45.63 | ........ | ........ |
| 8 | 19 | ....do.... | 2 | Middle... | 48,000 | .001667 | 92,000 | 19.67 | 37.51 | 7.8554 | 18.58 |
| 8 | 19 | ....do.... | 3 | Inside ... | 53,000 | .001933 | 95,200 | 22.50 | 40.28 | ........ | ........ |
| 8 | 20 | Muzzle.. | 1 | ....do .... | 46,000 | .001517 | 92,000 | 18.67 | 36.10 | ........ | ........ |
| 8 | 20 | ....do.... | 2 | Middle... | 49,000 | .001733 | 92,240 | 20.70 | 44.60 | ........ | ........ |
| 8 | 20 | ....do.... | 3 | Outside.. | 50,000 | .001767 | 91,600 | 20.33 | 48.22 | ........ | ........ |
| 8 | 20 | Breech .. | 1 | ....do .... | 48,000 | .001567 | 92,000 | 18.67 | 34.96 | ........ | ........ |
| 8 | 20 | ....do.... | 2 | Inside ... | 49,000 | .001767 | 92,400 | 20.33 | 43.25 | ........ | ........ |
| 8 | 20 | ....do.... | 3 | Middle... | 48,000 | .001733 | 91,160 | 20.30 | 36.40 | 7.8572 | 17.62 |
| 8 | 21 | Muzzle.. | 1 | Inside ... | 50,000 | .001667 | 94,800 | 19.33 | 45.11 | ........ | ........ |
| 8 | 21 | ....do.... | 2 | Middle... | 49,000 | .001783 | 93,600 | 19.17 | 29.12 | ........ | ........ |
| 8 | 21 | ....do.... | 3 | ....do .... | 49,000 | .001700 | 92,800 | 20.67 | 41.91 | ........ | ........ |
| 8 | 21 | Breech .. | 1 | Outside.. | 48,000 | .001667 | 94,800 | 21.33 | 41.64 | ........ | ........ |
| 8 | 21 | ....do.... | 2 | Inside ... | 50,000 | .001783 | 97,200 | 21.67 | 41.64 | ........ | ........ |
| 8 | 21 | ....do.... | 3 | Middle... | 47,000 | .001667 | 95,200 | 19.33 | 38.62 | 7.8583 | 17.53 |
| 8 | *22 | Muzzle.. | 1 | ....do .... | 47,000 | .......... | 92,000 | 20.83 | 46.93 | ........ | ........ |
| 8 | *22 | ....do.... | 2 | ....do .... | 49,000 | .......... | 92,000 | 22.00 | 46.15 | ........ | ........ |
| 8 | *22 | ....do.... | 3 | Inside ... | 49,000 | .......... | 93,200 | 21.67 | 49.48 | ........ | ........ |
| 8 | *22 | Breech .. | 1 | Outside.. | 44,000 | .......... | 92,400 | 20.00 | 42.18 | ........ | ........ |
| 8 | *22 | ....do.... | 2 | Inside ... | 46,000 | .......... | 92,400 | 16.00 | 15.96 | ........ | ........ |
| 8 | *22 | ....do.... | 3 | Middle... | —42,000 | .......... | 91,600 | 21.00 | 41.91 | ........ | ........ |
| 8 | 22 | ....do.... | 4 | Outside.. | 53,000 | .001900 | 94,800 | 20.33 | 48.47 | ........ | ........ |
| 8 | 22 | ....do.... | 5 | Inside ... | 50,000 | .001783 | 96,800 | 17.67 | 40.55 | ........ | ........ |
| 8 | 22 | ....do.... | 6 | Middle... | 50,000 | .001833 | 96,000 | 18.33 | 32.36 | 7.8545 | 20.25 |
| 8 | 22 | Muzzle.. | 4 | ....do .... | 52,000 | .001883 | 95,200 | 20.50 | 47.70 | ........ | ........ |
| 8 | 22 | ....do.... | 5 | ....do .... | 51,000 | .001783 | 96,400 | 20.17 | 39,45 | ........ | ........ |
| 8 | 22 | ....do.... | 6 | Inside ... | 51,000 | .001850 | 94,000 | 22.33 | 48.47 | ........ | ........ |
| 8 | 23 | ....do.... | 1 | Middle .. | 51,000 | .001733 | 95,360 | 18.00 | 36.40 | ........ | ........ |
| 8 | 23 | ....do.... | 2 | Inside ... | 49,000 | .001700 | 93,600 | 17.33 | 43.52 | ........ | ........ |
| 8 | 23 | ....do.... | 3 | Middle .. | 51,000 | .001800 | 95,200 | 19.83 | 43.25 | ........ | ........ |
| 8 | 23 | Breech .. | 1 | Outside.. | 49,000 | .001683 | 92,000 | 21.67 | 46.93 | ........ | ........ |
| 8 | 23 | ....do ... | 2 | Middle .. | 48,000 | .001733 | 88,120 | 22.00 | 44.60 | 7.8564 | 17.17 |
| 8 | 23 | ....do.... | 3 | Inside ... | 50,000 | .001733 | 90,400 | 23.83 | 48.72 | ........ | ........ |
| 8 | 24 | Muzzle.. | 1 | Outside.. | 49,000 | .001750 | 93,600 | 19.33 | 43.25 | ........ | ........ |
| 8 | 24 | ....do.... | 2 | Middle .. | 49,000 | .001733 | 92,400 | 17.33 | 38.90 | ........ | ........ |
| 8 | 24 | ....do.... | 3 | Inside ... | 51,000 | .001733 | 94,800 | 19.00 | 37.23 | ........ | ........ |
| 8 | 24 | Breech .. | 1 | Outside.. | 49,000 | .001733 | 92,400 | 20.33 | 43.79 | ........ | ........ |
| 8 | 24 | ....do.... | 2 | Inside ... | 48,000 | .001583 | 91,200 | 19.33 | 43.79 | ........ | ........ |
| 8 | 24 | ....do.... | 3 | Middle .. | 43,000 | .001433 | 90,400 | 21.00 | 38.07 | 7.8562 | 18.29 |
| 10 | †2 | Muzzle.. | 1 | Outside.. | 49,000 | .......... | 96,400 | 19.33 | 39.73 | ........ | ........ |
| 10 | †2 | ....do.... | 2 | Inside ... | 49,000 | .......... | 96,800 | 19.33 | 44.58 | ........ | ........ |
| 10 | †2 | ....do.... | 3 | Middle .. | 47,000 | .......... | 96,000 | 19.33 | 42.72 | ........ | ........ |
| 10 | †2 | Breech .. | 1 | Outside.. | 52,000 | .......... | 97,200 | 20.00 | 34.96 | ........ | ........ |
| 10 | †2 | ....do.... | 2 | Middle .. | 47,000 | .......... | 95,600 | 21.33 | 38.62 | ........ | ........ |
| 10 | †2 | ....do.... | 3 | Inside ... | 51,000 | .......... | 96,000 | 16.00 | 21.06 | ........ | ........ |
| 10 | *2 | ....do.... | 4 | ....do .... | 47,000 | .......... | 94,400 | 17.00 | 23.64 | ........ | ........ |
| 10 | *2 | ....do.... | 5 | Outside.. | 47,000 | .......... | 94,800 | 19.83 | 42.72 | ........ | ........ |
| 10 | *2 | ....do.... | 6 | Middle .. | 42,000 | .......... | 94,000 | 18.33 | 26.10 | ........ | ........ |
| 10 | 2 | Muzzle.. | 4 | Outside.. | 51,000 | .001850 | 93,600 | 20.50 | 46.67 | ........ | ........ |
| 10 | 2 | ....do.... | 5 | Inside ... | 49,000 | .001667 | 94,000 | 21.00 | 42.72 | ........ | ........ |
| 10 | 2 | ....do.... | 6 | Middle .. | 50,000 | .001783 | 93,200 | 18.67 | 43.79 | ........ | ........ |
| 10 | 2 | Breech .. | 7 | Outside.. | 50,000 | .001667 | 97,200 | 19.67 | 40.83 | ........ | ........ |
| 10 | 2 | ....do.... | 8 | Inside ... | 50,000 | .001717 | 95,200 | 19.33 | 33.81 | ........ | ........ |
| 10 | 2 | ....do.... | 9 | Middle .. | 46,000 | .001567 | 95,600 | 20.33 | 37.79 | 7.8562 | 19.39 |
| 10 | 3 | Muzzle.. | 1 | ....do .... | 45,000 | .001550 | 92,000 | 21.83 | 46.93 | ........ | ........ |
| 10 | 3 | ....do.... | 2 | ....do .... | 45,000 | .001550 | 89,600 | 21.83 | 46.41 | ........ | ........ |
| 10 | 3 | ....do.... | 3 | Inside ... | 46,000 | .001783 | 89,200 | 22.83 | 49.48 | ........ | ........ |
| 10 | 3 | Breech .. | 1 | Outside.. | 44,000 | .001467 | 97,600 | 19.00 | 41.37 | ........ | ........ |
| 10 | 3 | ...do.... | 2 | Inside ... | 48,000 | .001683 | 96,400 | 19.17 | 39.73 | ........ | ........ |
| 10 | 3 | ....do.... | 3 | Middle .. | 46,000 | .001550 | 94,000 | 18.67 | 38.62 | 7.8525 | 18.19 |
| 12 | 2 | Muzzle.. | 1 | Outside.. | 53,000 | .001767 | 92,400 | 20.33 | 47.96 | ........ | ........ |
| 12 | 2 | ....do.... | 2 | Inside ... | 52,000 | .001683 | 93,600 | 19.00 | 47.70 | ........ | ........ |
| 12 | 2 | ....do.... | 3 | Middle .. | 49,000 | .001633 | 90,400 | 22.67 | 43.52 | ........ | ........ |
| 12 | 2 | ....do.... | 4 | ....do .... | 47,000 | .001583 | 91,200 | 18.83 | 38.07 | ........ | ........ |
| 12 | 2 | Breech .. | 1 | Outside.. | 49,000 | .001667 | 91,200 | 20.33 | 46.67 | ........ | ........ |
| 12 | 2 | ....do.... | 2 | Middle .. | 42,000 | .001467 | 86,000 | 21.67 | 44.05 | ........ | ........ |
| 12 | 2 | ....do.... | 3 | Inside ... | 48,000 | .001650 | 88,800 | 23.33 | 47.70 | ........ | ........ |
| 12 | 2 | ....do.... | 4 | Middle .. | 43,000 | .001467 | 85,600 | 22.67 | 47.70 | 7.8550 | 16.7[illegible] |

* Not accepted on these results; retempered and annealed.
† Not accepted on these results; retested.

*Results of compression tests of tangential specimens from the breech end of tubes for 8-inch, 10-inch, and 12-inch B. L. rifles.*

[Length of specimen, 5 inches; sectional area, 1 square inch.]

| Caliber. | Number of tube. | Number of specimen. | Elastic limit per square inch of original section. | Ultimate strength per square inch of original section. |
|---|---|---|---|---|
| | | | *Pounds.* | *Pounds.* |
| 8 | 2 | 10 | 46,000 | 108,700 |
| 8 | 6 | 10 | 47,000 | 107,800 |
| 8 | 9 | 7 | 47,000 | 105,600 |
| 8 | 11 | 7 | 44,000 | 95,180 |
| 8 | 12 | 4 | 46,330 | 94,660 |
| 8 | 13 | 7 | 44,000 | 92,200 |
| 8 | 14 | 10 | 41,000 | 92,100 |
| 8 | 15 | 4 | 41,000 | 97,100 |
| 8 | 16 | 4 | 47,000 | 105,600 |
| 8 | 17 | 4 | 49,000 | 99,800 |
| 8 | 18 | 4 | 46,000 | 101,300 |
| 8 | 19 | 4 | 49,000 | 96,200 |
| 8 | 20 | 4 | 49,000 | 102,200 |
| 8 | 21 | 4 | 47,000 | 96,810 |
| 8 | 22 | 7 | 51,000 | 107,720 |
| 8 | 23 | 4 | 49,000 | 100,570 |
| 8 | 24 | 4 | 47,000 | 103,100 |
| 10 | 2 | 10 | 48,000 | 105,900 |
| 10 | 3 | 4 | 46,000 | 106,500 |
| 12 | 2 | 6 | 45,000 | 100,700 |

*Results of tensile tests of tangential specimens from ends of jackets for 8-inch, 10-inch, and 12-inch B. L. rifles.*

[Length of specimen, 3 inches; sectional area, 0.25 of a square inch.]

| Caliber. | Number of jacket. | Breech or muzzle. | Number of specimen. | Position of specimen. | Elastic limit per square inch of original section. | Elongation per inch under strain at elastic limit. | Tensile strength per square inch of original section. | Elongation after rupture. | Reduction in area after rupture. | Specific gravity. | Hardness. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Pounds.* | *Inch.* | *Pounds.* | *Per ct.* | *Per ct.* | | |
| 8 | 2 | Muzzle... | 13 | Outside.. | 54,000 | .001850 | 100,800 | 18.17 | 40.83 | ........ | ....... |
| 8 | 2 | ....do..... | 14 | Middle .. | 49,000 | .001717 | 98,400 | 18.00 | 39.45 | ........ | ....... |
| 8 | 2 | ....do..... | 15 | Inside ... | 54,000 | .001900 | 102,800 | 17.33 | 41.91 | ........ | ....... |
| 8 | 2 | ....do..... | 16 | Middle .. | 49,000 | .001783 | 99,200 | 17.33 | 38.35 | ........ | ....... |
| 8 | 2 | Breech ... | 13 | Outside.. | 51,000 | .001717 | 99,600 | 17.83 | 39.73 | ........ | ....... |
| 8 | 2 | ....do..... | 14 | Middle .. | 50,000 | .001800 | 98,000 | 18.17 | 39.73 | ........ | ....... |
| 8 | 2 | ....do..... | 15 | Inside ... | 53,000 | .001883 | 100,400 | 19.00 | 38.07 | ........ | ....... |
| 8 | 2 | ....do..... | 16 | Middle .. | 49,000 | .001733 | 97,200 | 19.33 | 37.23 | 7.8527 | 19.29 |
| 8 | *9 | Muzzle... | 1 | ....do .... | 52,000 | .......... | 102,400 | 13.67 | 23.95 | ........ | ....... |
| 8 | *9 | ....do..... | 2 | Inside ... | 53,000 | .......... | 102,800 | 13.00 | 34.10 | ........ | ....... |
| 8 | *9 | ....do..... | 3 | Middle .. | 49,000 | .......... | 94,000 | 19.00 | 38.07 | ........ | ....... |
| 8 | *9 | ....do..... | 4 | Outside.. | 54,000 | .......... | 105,600 | 15.83 | 39.45 | ........ | ....... |
| 8 | *9 | Breech ... | 1 | Middle .. | 49,000 | .......... | 100,200 | 12.67 | 19 60 | ........ | ....... |
| 8 | *9 | ....do..... | 2 | Inside ... | 55,000 | .......... | 105,200 | 14.33 | 31.49 | ........ | ....... |
| 8 | *9 | ....do..... | 3 | Middle .. | 49,000 | .......... | 99,200 | 14.33 | 25.80 | ........ | ....... |
| 8 | *9 | ....do..... | 4 | Outside.. | 50,000 | .......... | 94,800 | 17.00 | 39.18 | ........ | ....... |
| 8 | 9 | Muzzle... | 5 | ....do .... | 54,000 | .001917 | 98,800 | 19.00 | 51.97 | ........ | ....... |
| 8 | 9 | ....do..... | 6 | Middle .. | 45,000 | .001567 | 91,200 | 18.00 | 47.45 | ........ | ....... |
| 8 | 9 | ....do..... | 7 | Inside ... | 52,000 | .001833 | 95,600 | 17.33 | 47.19 | ........ | ....... |
| 8 | 9 | ....do..... | 8 | Middle .. | 46,000 | .001667 | 92,400 | 18.67 | 48.47 | ........ | ....... |
| 8 | 9 | Breech ... | 5 | Outside.. | 54,000 | .001850 | 98,000 | 19.00 | 49.73 | ........ | ....... |
| 8 | 9 | ....do..... | 6 | Middle .. | 44,000 | .001517 | 91,600 | 20.33 | 46.67 | ........ | ....... |
| 8 | 9 | . . do..... | 7 | Inside ... | 50,000 | .001700 | 96,400 | 19.67 | 51.73 | ........ | ....... |
| 8 | 9 | ....do..... | 8 | Middle .. | 44,000 | .001550 | 91,600 | 18.67 | 47.19 | 7.8584 | 16.82 |
| 8 | †10 | Muzzle... | 1 | Outside.. | 51,000 | .......... | 100,400 | 17.17 | 37.51 | ........ | ....... |
| 8 | †10 | ....do..... | 2 | Middle .. | 47,000 | .......... | 97,200 | 18.67 | 36.38 | ........ | ....... |
| 8 | †10 | ....do..... | 3 | Inside ... | 47,000 | .......... | 98,400 | 15.33 | 22.71 | ........ | ....... |
| 8 | †10 | ....do..... | 4 | Middle .. | 49,000 | .......... | 98,800 | 14.50 | 28.52 | ........ | ....... |

* Not accepted on these results; rcannealed.

† Not accepted on these results; retempered and annealed.

*Results of tensile tests of tangential specimens from ends of jackets for 8-inch, 10-inch, and 12-inch B. L. rifles*—Continued.

| Caliber. | Number of jacket. | Breech or muzzle. | Number of specimen. | Position of specimen. | Elastic limit per square inch of original section | Elongation per inch under strain at elastic limit. | Tensile strength per square inch of original section. | Elongation after rupture. | Reduction in area after rupture. | Specific gravity. | Hardness. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Pounds.* | *Inch.* | *Pounds.* | *Per ct.* | *Per ct.* | | |
| 8 | *10 | Breech... | 1 | Outside.. | 46,000 | .......... | 96,000 | 16.00 | 31.49 | ........ | ....... |
| 8 | *10 | ....do..... | 2 | Middle .. | 45,000 | .......... | 94,800 | 16.17 | 33.52 | ........ | ....... |
| 8 | *10 | ....do..... | 3 | Inside... | 52,000 | .......... | 100,000 | 12.67 | 21.77 | ........ | ....... |
| 8 | *10 | ....do..... | 4 | Middle .. | 46,000 | .......... | 93,600 | 17.33 | 35.53 | ........ | ....... |
| 8 | *10 | Muzzle... | 5 | Outside.. | 49,000 | .......... | 95,600 | 18.83 | 47.45 | ........ | ....... |
| 8 | *10 | ....do..... | 6 | Middle .. | 46,000 | .......... | 93,000 | 18.00 | 41.91 | ........ | ....... |
| 8 | *10 | ....do..... | 7 | Inside... | 47,000 | .......... | 94,800 | 18.33 | 47.19 | ........ | ....... |
| 8 | *10 | ....do..... | 8 | Middle .. | 47,000 | .......... | 94,000 | 19.50 | 45.37 | ........ | ....... |
| 8 | *10 | Breech... | 5 | Outside.. | 51,000 | .......... | 97,600 | 18.50 | 42.99 | ........ | ....... |
| 8 | *10 | ....do..... | 6 | Middle .. | —44,000 | .......... | 93,200 | 17.67 | 38.90 | ........ | ....... |
| 8 | *10 | ....de..... | 7 | Inside... | 48,000 | .......... | 97,200 | 14.00 | 24.57 | ........ | ....... |
| 8 | *10 | ....do..... | 8 | Middle .. | 46,000 | .......... | 94,400 | 21.33 | 47.45 | ........ | ....... |
| 8 | 10 | Muzzle... | 9 | Outside.. | 46,000 | .001617 | 94,800 | 14.00 | 14.99 | ........ | ....... |
| 8 | 10 | ....do..... | 10 | Middle .. | 44,000 | .001500 | 88,800 | 20.33 | 38.62 | ........ | ....... |
| 8 | 10 | ....do..... | 11 | Inside... | 47,000 | .001567 | 93,600 | 20.00 | 39.18 | ........ | ....... |
| 8 | 10 | ....do..... | 12 | Middle .. | 46,000 | .001617 | 90,400 | 20.50 | 40.55 | ........ | ....... |
| 8 | 10 | Breech... | 9 | Outside.. | 50,000 | .001750 | 98,000 | 19.33 | 38.62 | ........ | ....... |
| 8 | 10 | ....do..... | 10 | Middle .. | 46,000 | .001633 | 94,000 | 18.67 | 34.39 | ........ | ....... |
| 8 | 10 | ....do..... | 11 | Inside... | 49,000 | .001667 | 96,800 | 17.00 | 84.10 | ........ | ....... |
| 8 | 10 | ....do..... | 12 | Middle .. | 48,000 | .001717 | 92,400 | 15.33 | 23.33 | 7.8560 | 20.03 |
| 8 | 11 | Muzzle... | 1 | ....do.... | 47,000 | .001683 | 94,000 | 21.00 | 40.00 | ........ | ....... |
| 8 | 11 | ....do..... | 2 | Outside.. | 54,000 | .001933 | 99,200 | 20.00 | 44.05 | ........ | ....... |
| 8 | 11 | ....do..... | 3 | Middle .. | 52,000 | .001667 | 97,680 | 19.70 | 41.90 | ........ | ....... |
| 8 | 11 | ....do..... | 4 | Inside... | 52,000 | .001767 | 99,200 | 16.33 | 32.94 | ........ | ....... |
| 8 | 11 | ....do..... | 5 | Middle .. | 44,000 | .001517 | 92,400 | 20.33 | 42.18 | ........ | ....... |
| 8 | 11 | ....do..... | 6 | Inside... | 51,000 | .001667 | 97,880 | 19.70 | 41.90 | ........ | ....... |
| 8 | 11 | ....do..... | 7 | Outside.. | 53,000 | .001900 | 98,800 | 19.83 | 44.85 | ........ | ....... |
| 8 | 11 | ....do..... | 8 | Middle .. | 45,000 | .001583 | 94,000 | 20.00 | 38.62 | ........ | ....... |
| 8 | 11 | Breech... | 1 | ....do.... | 48,000 | .001667 | 90,000 | 17.33 | 33.52 | ........ | ....... |
| 8 | 11 | ....do..... | 2 | Outside.. | 53,000 | .001883 | 92,400 | 22.17 | 45.89 | ........ | ....... |
| 8 | 11 | ....do..... | 3 | Middle .. | 54,000 | .001800 | 91,160 | 20.30 | 47.20 | 7.8528 | 16.15 |
| 8 | 11 | ....do..... | 4 | Inside... | 54,000 | .001883 | 95,600 | 18.00 | 40.55 | ........ | ....... |
| 8 | *12 | Muzzle... | 1 | Outside.. | 53,000 | .......... | 97,200 | 20.00 | 39.73 | ........ | ....... |
| 8 | *12 | ....do..... | 2 | Middle .. | 50,000 | .......... | 94,000 | 21.33 | 43.25 | ........ | ....... |
| 8 | *12 | ....do..... | 3 | Inside... | 56,000 | .......... | 97,600 | 18.83 | 40.28 | ........ | ....... |
| 8 | *12 | ....do..... | 4 | Middle .. | 51,000 | .......... | 93,200 | 17.83 | 41.91 | ........ | ....... |
| 8 | *12 | Breech... | 1 | ....do.... | 46,000 | .......... | 88,800 | 21.33 | 44.05 | ........ | ....... |
| 8 | *12 | ....do..... | 2 | Outside.. | 53,000 | .......... | 95,200 | 18.33 | 33.23 | ........ | ....... |
| 8 | *12 | ....do..... | 3 | Middle .. | —44,000 | .......... | 87,200 | 23.83 | 45.37 | ........ | ....... |
| 8 | *12 | ....do..... | 4 | Inside... | —44,000 | .......... | 85,600 | 24.33 | 48.47 | ........ | ....... |
| 8 | 12 | Muzzle... | 5 | Outside.. | 54,000 | .001983 | 100,000 | 17.33 | 41.37 | ........ | ....... |
| 8 | 12 | ....do..... | 6 | Middle .. | 52,000 | .001867 | 99,200 | 16.83 | 35.82 | ........ | ....... |
| 8 | 12 | ....do..... | 7 | ....do.... | 49,000 | .001817 | 99,600 | 18.33 | 40.28 | ........ | ....... |
| 8 | 12 | ....do..... | 8 | Inside... | 53,000 | .001950 | 101,200 | 18.67 | 44.58 | ........ | ....... |
| 8 | 12 | Breech... | 5 | Outside.. | 54,000 | .001900 | 103,600 | 18.67 | 38.90 | ........ | ....... |
| 8 | 12 | ....do..... | 6 | Middle .. | 50,000 | .001783 | 100,800 | 17.50 | 36.38 | ........ | ....... |
| 8 | 12 | ....do..... | 7 | ....do.... | 51,000 | .001833 | 100,800 | 17.67 | 32.07 | 7.8545 | 20.03 |
| 8 | 12 | ....do..... | 8 | Inside... | 52,000 | .001850 | 100,000 | 18.00 | 31.49 | ........ | ....... |
| 8 | 13 | Muzzle... | 1 | Outside.. | 52,000 | .001833 | 94,800 | 19.67 | 45.63 | ........ | ....... |
| 8 | 13 | ....do..... | 2 | Middle .. | 48,000 | .001633 | 93,200 | 20.33 | 41.91 | ........ | ....... |
| 8 | 13 | ....do..... | 3 | Inside... | 51,000 | .001833 | 96,400 | 17.83 | 42.99 | ........ | ....... |
| 8 | 13 | ....do..... | 4 | Middle .. | 49,000 | .001717 | 95,600 | 19.33 | 37.79 | ........ | ....... |
| 8 | 13 | Breech... | 1 | Outside.. | 50,000 | .001767 | 96,400 | 19.00 | 43.52 | ........ | ....... |
| 8 | 13 | ....do..... | 2 | Middle .. | 46,000 | .001667 | 91,200 | 18.67 | 39.18 | ........ | ....... |
| 8 | 13 | ....do..... | 3 | Inside... | 47,000 | .001650 | 89,200 | 17.00 | 88.62 | ........ | ....... |
| 8 | 13 | ....do..... | 4 | Middle .. | 47,000 | .001683 | 90,400 | 20.00 | 39.18 | 7.8533 | 18.09 |
| 8 | 14 | Muzzle... | 1 | Outside.. | 49,000 | .001683 | 95,200 | 20.33 | 47.45 | ........ | ....... |
| 8 | 14 | ....do..... | 2 | Middle .. | 50,000 | .001733 | 92,720 | 20.00 | 44.60 | ........ | ....... |
| 8 | 14 | ....do..... | 3 | Inside... | 50,000 | .001783 | 97,200 | 16.50 | 37.51 | ........ | ....... |
| 8 | 14 | ....do..... | 4 | Middle .. | 49,000 | .001717 | 94,800 | 19.00 | 41.91 | ........ | ....... |
| 8 | 14 | ....do..... | 5 | Outside.. | 51,000 | .001817 | 95,600 | 20.67 | 46.15 | ........ | ....... |
| 8 | 14 | ....do..... | 6 | Middle .. | 47,000 | .001633 | 91,240 | 19.70 | 39.20 | ........ | ....... |
| 8 | 14 | ....do..... | 7 | Inside... | 50,000 | .001817 | 94,800 | 21.00 | 46.15 | ........ | ....... |
| 8 | 14 | ....do..... | 8 | Middle .. | 45,000 | .001617 | 91,600 | 21.17 | 40.83 | ........ | ....... |
| 8 | 14 | Breech... | 1 | Outside.. | 48,000 | .001750 | 92,400 | 20.67 | 46.93 | ........ | ....... |
| 8 | 14 | ....do..... | 2 | Middle .. | 50,000 | .001767 | 91,880 | 20.30 | 44.60 | ........ | ....... |
| 8 | 14 | ....do..... | 3 | Inside... | 52,000 | .001833 | 94,400 | 17.00 | 27.01 | ........ | ....... |
| 8 | 14 | ....do..... | 4 | Middle .. | 48,000 | .001717 | 90,000 | 22.17 | 47.70 | 7.8517 | 17.53 |

* Not accepted on these results; retempered and annealed.

*Results of tensile tests of tangential specimens from ends of jackets for 8-inch, 10-inch, and 12-inch B. L. rifles*—Continued.

| Caliber. | Number of jacket. | Breech or muzzle. | Number of specimen. | Position of specimen. | Elastic limit per square inch of original section. | Elongation per inch under strain at elastic limit. | Tensile strength per square inch of original section. | Elongation after rupture. | Reduction in area after rupture. | Specific gravity. | Hardness. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Pounds.* | *Inch.* | *Pounds.* | *Per ct.* | *Per ct.* | | |
| 8 | 15 | **Muzzle...** | 1 | Outside.. | 55,000 | .001933 | 99,200 | 19.67 | 47.45 | ........ | ....... |
| 8 | 15 | ....do..... | 2 | Middle .. | 50,000 | .001733 | 98,800 | 17.17 | 41.10 | ........ | ....... |
| 8 | 15 | ....do..... | 3 | Inside ... | 52,000 | .001867 | 100,400 | 21.50 | 44.32 | ........ | ....... |
| 8 | 15 | ....do..... | 4 | Middle .. | 47,000 | .001750 | 97,600 | 20.00 | 39.45 | ........ | ....... |
| 8 | 15 | **Breech ...** | 1 | Inside ... | 52,000 | .001767 | 98,400 | 18.00 | 30.31 | ........ | ....... |
| 8 | 15 | ....do..... | 2 | Middle .. | 49,000 | .001833 | 97,600 | 15.33 | 30.60 | ........ | ....... |
| 8 | 15 | ....do..... | 3 | Outside.. | 53,000 | .002000 | 100,800 | 18.67 | 39.18 | ........ | ....... |
| 8 | 15 | ....do..... | 4 | Middle .. | 46,000 | .001633 | 96,800 | 20.67 | 40.00 | 7.8584 | 18.78 |
| 8 | 16 | **Muzzle...** | 1 | Outside.. | 52,000 | .001950 | 96,800 | 20.67 | 42.72 | ........ | ....... |
| 8 | 16 | ....do..... | 2 | Middle .. | 47,000 | .001567 | 93,200 | 20.33 | 43.52 | ........ | ....... |
| 8 | 16 | ....do..... | 3 | Inside. .. | 51,000 | .001750 | 97,200 | 19.33 | 44.85 | ........ | ....... |
| 8 | 16 | ....do..... | 4 | Middle .. | 48,000 | .001717 | 96,000 | 20.83 | 29.12 | ........ | ....... |
| 8 | 16 | **Breech ...** | 1 | Outside.. | 52,000 | .001817 | 97,200 | 19.67 | 43.79 | ........ | ....... |
| 8 | 16 | ....do..... | 2 | Middle .. | 50,000 | .001767 | 95,600 | 19.67 | 43.79 | ........ | ....... |
| 8 | 16 | ....do..... | 3 | Inside ... | 52,000 | .001883 | 97,600 | 19.67 | 42.18 | ........ | ....... |
| 8 | 16 | ....do..... | 4 | Middle .. | 47,000 | .001750 | 95,600 | 16.33 | 26.41 | 7.8525 | 19.60 |
| 8 | 17 | **Muzzle...** | 1 | Outside.. | 53,000 | .001817 | 95,600 | 20.00 | 45.37 | ........ | ....... |
| 8 | 17 | ....do..... | 2 | Middle .. | 52,000 | .001767 | 99,680 | 19.70 | 41.90 | ........ | ....... |
| 8 | 17 | ....do..... | 3 | Inside ... | 55,000 | .001883 | 99,200 | 21.67 | 48.72 | ........ | ....... |
| 8 | 17 | ....do..... | 4 | Middle .. | 51,000 | .001667 | 98,000 | 22.33 | 44.85 | ........ | ....... |
| 8 | 17 | **Breech ...** | 1 | Outside.. | 54,000 | .001817 | 98,400 | 20.33 | 45.89 | ........ | ....... |
| 8 | 17 | ....do..... | 2 | Middle... | 51,000 | .001667 | 97,640 | 19.00 | 44.60 | ........ | ....... |
| 8 | 17 | ....do..... | 3 | Inside ... | 56,000 | .001900 | 100,800 | 17.00 | 44.05 | ........ | ....... |
| 8 | 17 | ....do..... | 4 | Middle .. | 51,000 | .001733 | 100,400 | 18.17 | 37.79 | 7.8566 | 20.25 |
| 8 | 18 | **Muzzle...** | 1 | ....do .... | 47,000 | .001600 | 92,400 | 19.00 | 45.37 | ........ | ....... |
| 8 | 18 | ....do..... | 2 | Outside.. | 52,000 | .001783 | 94,400 | 19.67 | 43.25 | ........ | ....... |
| 8 | 18 | ....do..... | 3 | Middle .. | 48,000 | .001650 | 92,800 | 21.67 | 45.89 | ........ | ....... |
| 8 | 18 | ....do..... | 4 | Inside ... | 53,000 | .001867 | 94,000 | 19.67 | 47.45 | ........ | ....... |
| 8 | 18 | **Breech ...** | 1 | Middle .. | 47,000 | .001750 | 96,800 | 18.00 | 29.71 | ........ | ....... |
| 8 | 18 | ....do..... | 2 | Outside.. | 50,000 | .001767 | 96,800 | 22.50 | 44.05 | ........ | ....... |
| 8 | 18 | ....do..... | 3 | Middle .. | 49,000 | .001783 | 93,200 | 20.00 | 40.83 | 7.8526 | 17.99 |
| 8 | 18 | ....do..... | 4 | Inside ... | 50,000 | .001717 | 99,200 | 17.67 | 33.52 | ........ | ....... |
| 8 | 19 | **Muzzle...** | 1 | Outside.. | 55,000 | .001817 | 102,000 | 20.00 | 43.52 | ........ | ....... |
| 8 | 19 | ....do..... | 2 | Middle .. | 49,000 | .001650 | 97,800 | 18.00 | 40.00 | ........ | ....... |
| 8 | 19 | ....do..... | 3 | ....do .... | 51,000 | .001717 | 98,400 | 17.67 | 36.10 | ........ | ....... |
| 8 | 19 | ....do..... | 4 | Inside ... | 53,000 | .001817 | 100,400 | 17.00 | 46.41 | ........ | ....... |
| 8 | 19 | **Breech ...** | 1 | Outside.. | 54,000 | .001817 | 102,800 | 18.00 | 41.64 | ........ | ....... |
| 8 | 19 | ....do..... | 2 | Inside ... | 54,000 | .001833 | 103,600 | 18.33 | 42.45 | ........ | ....... |
| 8 | 19 | ....do..... | 3 | Middle .. | 51,000 | .001750 | 100,000 | 14.83 | 23.02 | ........ | ....... |
| 8 | 19 | ....do..... | 4 | ....do .... | 50,000 | .001650 | 98,400 | 16.33 | 32.36 | 7.8542 | 19.81 |
| 8 | 20 | **Muzzle...** | 1 | Outside.. | 49,000 | .001717 | 97,200 | 17.17 | 40.55 | ........ | ....... |
| 8 | 20 | ....do..... | 2 | Middle .. | 51,000 | .001800 | 100,040 | 18.30 | 36.40 | ........ | ....... |
| 8 | 20 | ....do..... | 3 | Inside ... | 54,000 | .001883 | 100,000 | 17.33 | 37.79 | ........ | ....... |
| 8 | 20 | ....do..... | 4 | Middle .. | 50,000 | .001767 | 99,600 | 16.50 | 40.28 | ........ | ....... |
| 8 | 20 | **Breech ...** | 1 | Outside.. | 51,000 | .001833 | 98,000 | 17.00 | 40.28 | ........ | ....... |
| 8 | 20 | ....do..... | 2 | Middle .. | 49,000 | .001633 | 96,440 | 19.70 | 44.60 | ........ | ....... |
| 8 | 20 | ....do..... | 3 | Inside ... | 49,000 | .001683 | 96,800 | 19.50 | 41.91 | ........ | ....... |
| 8 | 20 | ....do..... | 4 | Middle .. | 46,000 | .001667 | 96,800 | 20.67 | 36.94 | 7.8566 | 19.49 |
| 8 | *21 | **Muzzle...** | 1 | Outside.. | 52,000 | .......... | 100,800 | 17.33 | 40.00 | ........ | ....... |
| 8 | *21 | ....do..... | 2 | Middle .. | 49,000 | .......... | 98,800 | 11.50 | 14.64 | ........ | ....... |
| 8 | *21 | ....do..... | 3 | ....do .... | 50,000 | .......... | 98,800 | 18.50 | 38.90 | ........ | ....... |
| 8 | *21 | ....do..... | 4 | Inside ... | 55,000 | .......... | 104,000 | 17.17 | 40.00 | ........ | ....... |
| 8 | *21 | **Breech ...** | 1 | Outside.. | 52,000 | .......... | 100,000 | 20.00 | 44.85 | ........ | ....... |
| 8 | *21 | ....do..... | 2 | Middle .. | 49,000 | .......... | 98,000 | 18.50 | 35.82 | ........ | ....... |
| 8 | *21 | ....do..... | 3 | Inside ... | 55,000 | .......... | 102,000 | 18.67 | 44.85 | ........ | ....... |
| 8 | *21 | ....do..... | 4 | Middle .. | 49,000 | .......... | 96,800 | 19.33 | 40.55 | ........ | ....... |
| 8 | †21 | **Muzzle...** | 5 | Outside.. | 50,000 | .......... | 96,000 | 17.00 | 22.71 | ........ | ....... |
| 8 | †21 | ....do..... | 6 | Middle... | —44,000 | .......... | 92,800 | 18.33 | 35.82 | ........ | ....... |
| 8 | †21 | ....do..... | 7 | Inside ... | 50,000 | .......... | 97,200 | 20.00 | 43.52 | ........ | ....... |
| 8 | †21 | ....do..... | 8 | Middle... | 46,000 | .......... | 93,600 | 21.67 | 41.64 | ........ | ....... |
| 8 | †21 | **Breech ...** | 5 | Outside.. | 50,000 | .......... | 96,000 | 21.00 | 47.96 | ........ | ....... |
| 8 | †21 | ....do..... | 6 | Middle... | —44,000 | .......... | 91,600 | 20.33 | 38.07 | ........ | ....... |
| 8 | †21 | ....do..... | 7 | Inside ... | 50,000 | .......... | 98,000 | 16.67 | 26.41 | ........ | ....... |
| 8 | †21 | ....do..... | 8 | Middle... | —44,000 | .......... | 92,000 | 22.00 | 41.91 | ........ | ....... |
| 8 | 21 | **Muzzle...** | 9 | Outside.. | 54,000 | .001917 | 97,200 | 20.67 | 45.11 | ........ | ....... |
| 8 | 21 | ....do..... | 10 | Middle... | 47,000 | .001683 | 94,400 | 19.67 | 36.94 | ........ | ....... |
| 8 | 21 | ....do..... | 11 | Inside ... | 54,000 | .001917 | 99,600 | 18.67 | 47.45 | ........ | ....... |
| 8 | 21 | ....do..... | 12 | Middle... | 52,000 | .001883 | 97,600 | 18.67 | 40.55 | ........ | ....... |

* Not accepted on these results; reannealed.

† Not accepted on these results; retempered and annealed.

*Results of tensile tests of tangential specimens from ends of jackets for 8-inch, 10-inch, and 12-inch B. L. rifles*—Continued.

| Caliber. | Number of jacket. | Breech or muzzle. | Number of specimen. | Position of specimen. | Elastic limit per square inch of original section | Elongation per inch under strain at elastic limit. | Tensile strength per square inch of original section. | Elongation after rupture. | Reduction in area after rupture. | Specific gravity. | Hardness. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Pounds.* | *Inch.* | *Pounds.* | *Per ct.* | *Per ct.* | | |
| 8 | *10 | Breech | 1 | Outside | 46,000 | .......... | 96,000 | 16.00 | 31.49 | .......... | .......... |
| 8 | *10 | ....do..... | 2 | Middle | 45,000 | .......... | 94,800 | 16.17 | 33.52 | .......... | .......... |
| 8 | *10 | ....do..... | 3 | Inside | 52,000 | .......... | 100,000 | 12.67 | 21.77 | .......... | .......... |
| 8 | *10 | ....do..... | 4 | Middle | 46,000 | .......... | 93,600 | 17.33 | 35.53 | .......... | .......... |
| 8 | *10 | Muzzle | 5 | Outside | 49,000 | .......... | 95,600 | 18.83 | 47.45 | .......... | .......... |
| 8 | *10 | ....do..... | 6 | Middle | 46,000 | .......... | 93,000 | 18.00 | 41.91 | .......... | .......... |
| 8 | *10 | ....do..... | 7 | Inside | 47,000 | .......... | 94,800 | 18.33 | 47.19 | .......... | .......... |
| 8 | *10 | ....do..... | 8 | Middle | 47,000 | .......... | 94,000 | 19.50 | 45.37 | .......... | .......... |
| 8 | *10 | Breech | 5 | Outside | 51,000 | .......... | 97,600 | 18.50 | 42.99 | .......... | .......... |
| 8 | *10 | ....do..... | 6 | Middle | —44,000 | .......... | 93,200 | 17.67 | 38.90 | .......... | .......... |
| 8 | *10 | ....do..... | 7 | Inside | 48,000 | .......... | 97,200 | 14.00 | 24.57 | .......... | .......... |
| 8 | *10 | ....do..... | 8 | Middle | 46,000 | .......... | 94,400 | 21.33 | 47.45 | .......... | .......... |
| 8 | 10 | Muzzle | 9 | Outside | 46,000 | .001617 | 94,800 | 14.00 | 14.99 | .......... | .......... |
| 8 | 10 | ....do..... | 10 | Middle | 44,000 | .001500 | 88,800 | 20.33 | 38.62 | .......... | .......... |
| 8 | 10 | ....do..... | 11 | Inside | 47,000 | .001567 | 93,600 | 20.00 | 39.18 | .......... | .......... |
| 8 | 10 | ....do..... | 12 | Middle | 46,000 | .001617 | 90,400 | 20.50 | 40.55 | .......... | .......... |
| 8 | 10 | Breech | 9 | Outside | 50,000 | .001750 | 98,000 | 19.33 | 38.62 | .......... | .......... |
| 8 | 10 | ....do..... | 10 | Middle | 46,000 | .001633 | 94,000 | 18.67 | 34.39 | .......... | .......... |
| 8 | 10 | ....do..... | 11 | Inside | 49,000 | .001667 | 96,800 | 17.00 | 34.10 | .......... | .......... |
| 8 | 10 | ....do..... | 12 | Middle | 48,000 | .001717 | 92,400 | 15.33 | 23.33 | 7.8560 | 20.03 |
| 8 | 11 | Muzzle | 1 | ....do.... | 47,000 | .001683 | 94,000 | 21.00 | 40.00 | .......... | .......... |
| 8 | 11 | ....do..... | 2 | Outside | 54,000 | .001933 | 99,200 | 20.00 | 44.05 | .......... | .......... |
| 8 | 11 | ....do..... | 3 | Middle | 52,000 | .001667 | 97,680 | 19.70 | 41.90 | .......... | .......... |
| 8 | 11 | ....do..... | 4 | Inside | 52,000 | .001767 | 99,200 | 16.33 | 32.94 | .......... | .......... |
| 8 | 11 | ....do..... | 5 | Middle | 44,000 | .001517 | 92,400 | 20.33 | 42.18 | .......... | .......... |
| 8 | 11 | ....do..... | 6 | Inside | 51,000 | .001667 | 97,880 | 19.70 | 41.90 | .......... | .......... |
| 8 | 11 | ....do..... | 7 | Outside | 53,000 | .001900 | 98,800 | 19.83 | 44.85 | .......... | .......... |
| 8 | 11 | ....do..... | 8 | Middle | 45,000 | .001583 | 94,000 | 20.00 | 38.62 | .......... | .......... |
| 8 | 11 | Breech | 1 | ....do.... | 48,000 | .001667 | 90,000 | 17.33 | 33.52 | .......... | .......... |
| 8 | 11 | ....do..... | 2 | Outside | 53,000 | .001883 | 92,400 | 22.17 | 45.89 | .......... | .......... |
| 8 | 11 | ....do..... | 3 | Middle | 54,000 | .001800 | 91,160 | 20.30 | 47.20 | 7.8528 | 16.15 |
| 8 | 11 | ....do..... | 4 | Inside | 54,000 | .001883 | 95,600 | 18.00 | 40.55 | .......... | .......... |
| 8 | *12 | Muzzle | 1 | Outside | 53,000 | .......... | 97,200 | 20.00 | 39.73 | .......... | .......... |
| 8 | *12 | ....do..... | 2 | Middle | 50,000 | .......... | 94,000 | 21.33 | 43.25 | .......... | .......... |
| 8 | *12 | ....do..... | 3 | Inside | 56,000 | .......... | 97,600 | 18.83 | 40.28 | .......... | .......... |
| 8 | *12 | ....do..... | 4 | Middle | 51,000 | .......... | 93,200 | 17.83 | 41.91 | .......... | .......... |
| 8 | *12 | Breech | 1 | ....do.... | 46,000 | .......... | 88,800 | 21.33 | 44.05 | .......... | .......... |
| 8 | *12 | ....do..... | 2 | Outside | 53,000 | .......... | 95,200 | 18.33 | 33.23 | .......... | .......... |
| 8 | *12 | ....do..... | 3 | Middle | —44,000 | .......... | 87,200 | 23.83 | 45.37 | .......... | .......... |
| 8 | *12 | ....do..... | 4 | Inside | —44,000 | .......... | 85,600 | 24.33 | 48.47 | .......... | .......... |
| 8 | 12 | Muzzle | 5 | Outside | 54,000 | .001983 | 100,000 | 17.33 | 41.37 | .......... | .......... |
| 8 | 12 | ....do..... | 6 | Middle | 52,000 | .001867 | 99,200 | 16.83 | 35.82 | .......... | .......... |
| 8 | 12 | ....do..... | 7 | ....do.... | 49,000 | .001817 | 99,600 | 18.33 | 40.28 | .......... | .......... |
| 8 | 12 | ....do..... | 8 | Inside | 53,000 | .001950 | 101,200 | 18.67 | 44.58 | .......... | .......... |
| 8 | 12 | Breech | 5 | Outside | 54,000 | .001900 | 103,600 | 18.67 | 38.90 | .......... | .......... |
| 8 | 12 | ....do..... | 6 | Middle | 50,000 | .001783 | 100,800 | 17.50 | 36.38 | .......... | .......... |
| 8 | 12 | ....do..... | 7 | ....do.... | 51,000 | .001833 | 100,800 | 17.67 | 32.07 | 7.8545 | 20.03 |
| 8 | 12 | ....do..... | 8 | Inside | 52,000 | .001850 | 100,000 | 18.00 | 31.49 | .......... | .......... |
| 8 | 13 | Muzzle | 1 | Outside | 52,000 | .001833 | 94,800 | 19.67 | 45.63 | .......... | .......... |
| 8 | 13 | ....do..... | 2 | Middle | 48,000 | .001633 | 93,200 | 20.33 | 41.91 | .......... | .......... |
| 8 | 13 | ....do..... | 3 | Inside | 51,000 | .001833 | 96,400 | 17.83 | 42.99 | .......... | .......... |
| 8 | 13 | ....do..... | 4 | Middle | 49,000 | .001717 | 95,600 | 19.33 | 37.79 | .......... | .......... |
| 8 | 13 | Breech | 1 | Outside | 50,000 | .001767 | 96,400 | 19.00 | 43.52 | .......... | .......... |
| 8 | 13 | ....do..... | 2 | Middle | 46,000 | .001667 | 91,200 | 18.67 | 39.18 | .......... | .......... |
| 8 | 13 | ....do..... | 3 | Inside | 47,000 | .001650 | 89,200 | 17.00 | 38.62 | .......... | .......... |
| 8 | 13 | ....do..... | 4 | Middle | 47,000 | .001683 | 90,400 | 20.00 | 39.18 | 7.8533 | 18.09 |
| 8 | 14 | Muzzle | 1 | Outside | 49,000 | .001683 | 95,200 | 20.33 | 47.45 | .......... | .......... |
| 8 | 14 | ....do..... | 2 | Middle | 50,000 | .001733 | 92,720 | 20.00 | 44.60 | .......... | .......... |
| 8 | 14 | ....do..... | 3 | Inside | 50.000 | .001783 | 97,200 | 16.50 | 37.51 | .......... | .......... |
| 8 | 14 | ....do..... | 4 | Middle | 49,000 | .001717 | 94,800 | 19.00 | 41.91 | .......... | .......... |
| 8 | 14 | ....do..... | 5 | Outside | 51,000 | .001817 | 95,600 | 20.67 | 46.15 | .......... | .......... |
| 8 | 14 | ....do..... | 6 | Middle | 47,000 | .001633 | 91,240 | 19.70 | 39.20 | .......... | .......... |
| 8 | 14 | ....do..... | 7 | Inside | 50,000 | .001817 | 94,800 | 21.00 | 46.15 | .......... | .......... |
| 8 | 14 | ....do..... | 8 | Middle | 45,000 | .001617 | 91,600 | 21.17 | 40.83 | .......... | .......... |
| 8 | 14 | Breech | 1 | Outside | 48,000 | .001750 | 92,400 | 20.67 | 46.93 | .......... | .......... |
| 8 | 14 | ....do..... | 2 | Middle | 50,000 | .001767 | 91,880 | 20.30 | 44.60 | .......... | .......... |
| 8 | 14 | ....do..... | 3 | Inside | 52,000 | .001833 | 94,400 | 17.00 | 27.01 | .......... | .......... |
| 8 | 14 | ....do..... | 4 | Middle | 48,000 | .001717 | 90,000 | 22.17 | 47.70 | 7.8517 | 17.53 |

* Not accepted on these results; retempered and annealed.

*Results of tensile tests of tangential specimens from ends of jackets for 8-inch, 10-inch, and 12-inch B. L. rifles*—Continued.

| Caliber. | Number of jacket. | Breech or muzzle. | Number of specimen. | Position of specimen. | Elastic limit per square inch of original section. | Elongation per inch under strain at elastic limit. | Tensile strength per square inch of original section. | Elongation after rupture. | Reduction in area after rupture. | Specific gravity. | Hardness. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Pounds.* | *Inch.* | *Pounds.* | *Per ct.* | *Per ct.* | | |
| 8 | 15 | Muzzle... | 1 | Outside.. | 55,000 | .001933 | 99,200 | 19.67 | 47.45 | ........ | ....... |
| 8 | 15 | ....do..... | 2 | Middle .. | 50,000 | .001733 | 98,800 | 17.17 | 41.10 | ........ | ....... |
| 8 | 15 | ....do..... | 3 | Inside ... | 52,000 | .001867 | 100,400 | 21.50 | 44.32 | ........ | ....... |
| 8 | 15 | ....do..... | 4 | Middle .. | 47,000 | .001750 | 97,600 | 20.00 | 39.45 | ........ | ....... |
| 8 | 15 | Breech ... | 1 | Inside ... | 52,000 | .001767 | 98,400 | 18.00 | 30.31 | ........ | ....... |
| 8 | 15 | ....do..... | 2 | Middle .. | 49,000 | .001833 | 97,600 | 15.33 | 30.60 | ........ | ....... |
| 8 | 15 | ....do..... | 3 | Outside.. | 53,000 | .002000 | 100,800 | 18.67 | 39.18 | ........ | ....... |
| 8 | 15 | ....do..... | 4 | Middle .. | 46,000 | .001633 | 96,800 | 20.67 | 40.00 | 7.8584 | 18.78 |
| 8 | 16 | Muzzle... | 1 | Outside.. | 52,000 | .001950 | 96,800 | 20.67 | 42.72 | ........ | ....... |
| 8 | 16 | ....do..... | 2 | Middle .. | 47,000 | .001567 | 93,200 | 20.33 | 43.52 | ........ | ....... |
| 8 | 16 | ....do..... | 3 | Inside. .. | 51,000 | .001750 | 97,200 | 19.33 | 44.85 | ........ | ....... |
| 8 | 16 | ....do..... | 4 | Middle .. | 48,000 | .001717 | 96,000 | 20.83 | 29.12 | ........ | ....... |
| 8 | 16 | Breech ... | 1 | Outside.. | 52,000 | .001817 | 97,200 | 19.67 | 43.79 | ........ | ....... |
| 8 | 16 | ....do..... | 2 | Middle .. | 50,000 | .001767 | 95,600 | 19.67 | 43.79 | ........ | ....... |
| 8 | 16 | ....do..... | 3 | Inside ... | 52,000 | .001883 | 97,600 | 19.67 | 42.18 | ........ | ....... |
| 8 | 16 | ....do..... | 4 | Middle .. | 47,000 | .001750 | 95,600 | 16.33 | 26.41 | 7.8525 | 19.60 |
| 8 | 17 | Muzzle... | 1 | Outside.. | 53,000 | .001817 | 95,600 | 20.00 | 45.37 | ........ | ....... |
| 8 | 17 | ....do..... | 2 | Middle .. | 52,000 | .001767 | 99,680 | 19.70 | 41.90 | ........ | ....... |
| 8 | 17 | ....do..... | 3 | Inside ... | 55,000 | .001883 | 99,200 | 21.67 | 48.72 | ........ | ....... |
| 8 | 17 | ....do..... | 4 | Middle .. | 51,000 | .001667 | 98,000 | 22.33 | 44.85 | ........ | ....... |
| 8 | 17 | Breech ... | 1 | Outside.. | 54,000 | .001817 | 98,400 | 20.33 | 45.89 | ........ | ....... |
| 8 | 17 | ....do..... | 2 | Middle... | 51,000 | .001667 | 97,640 | 19.00 | 44.60 | ........ | ....... |
| 8 | 17 | ....do..... | 3 | Inside ... | 56,000 | .001900 | 100,800 | 17.00 | 44.05 | ........ | ....... |
| 8 | 17 | ....do..... | 4 | Middle .. | 51,000 | .001733 | 100,400 | 18.17 | 37.79 | 7.8566 | 20.25 |
| 8 | 18 | Muzzle... | 1 | ....do .... | 47,000 | .001600 | 92,400 | 19.00 | 45.37 | ........ | ....... |
| 8 | 18 | ....do..... | 2 | Outside.. | 52,000 | .001783 | 94,400 | 19.67 | 43.25 | ........ | ....... |
| 8 | 18 | ....do..... | 3 | Middle .. | 48,000 | .001650 | 92,800 | 21.67 | 45.89 | ........ | ....... |
| 8 | 18 | ....do..... | 4 | Inside ... | 53,000 | .001867 | 94,000 | 19.67 | 47.45 | ........ | ....... |
| 8 | 18 | Breech ... | 1 | Middle .. | 47,000 | .001750 | 96,800 | 18.00 | 29.71 | ........ | ....... |
| 8 | 18 | ....do..... | 2 | Outside.. | 50,000 | .001767 | 96,800 | 22.50 | 44.05 | ........ | ....... |
| 8 | 18 | ....do..... | 3 | Middle .. | 49,000 | .001783 | 93,200 | 20.00 | 40.83 | 7.8526 | 17.99 |
| 8 | 18 | ....do..... | 4 | Inside ... | 50,000 | .001717 | 99,200 | 17.67 | 33.52 | ........ | ....... |
| 8 | 19 | Muzzle... | 1 | Outside.. | 55,000 | .001817 | 102,000 | 20.00 | 43.52 | ........ | ....... |
| 8 | 19 | ....do..... | 2 | Middle .. | 49,000 | .001650 | 97,800 | 18.00 | 40.00 | ........ | ....... |
| 8 | 19 | ....do..... | 3 | ....do .... | 51,000 | .001717 | 98,400 | 17.67 | 36.10 | ........ | ....... |
| 8 | 19 | ....do..... | 4 | Inside ... | 53,000 | .001817 | 100,400 | 17.00 | 46.41 | ........ | ....... |
| 8 | 19 | Breech ... | 1 | Outside.. | 54,000 | .001817 | 102,800 | 18.00 | 41.64 | ........ | ....... |
| 8 | 19 | ....do..... | 2 | Inside ... | 54,000 | .001833 | 103,600 | 18.33 | 42.45 | ........ | ....... |
| 8 | 19 | ....do..... | 3 | Middle .. | 51,000 | .001750 | 100,000 | 14.83 | 23.02 | ........ | ....... |
| 8 | 19 | ....do..... | 4 | ....do .... | 50,000 | .001650 | 98,400 | 16.33 | 32.36 | 7.8542 | 19.81 |
| 8 | 20 | Muzzle... | 1 | Outside.. | 49,000 | .001717 | 97,200 | 17.17 | 40.55 | ........ | ....... |
| 8 | 20 | ....do..... | 2 | Middle .. | 51,000 | .001800 | 100,040 | 18.30 | 36.40 | ........ | ....... |
| 8 | 20 | ....do..... | 3 | Inside ... | 54,000 | .001883 | 100,000 | 17.33 | 37.79 | ........ | ....... |
| 8 | 20 | ....do..... | 4 | Middle .. | 50,000 | .001767 | 99,600 | 16.50 | 40.28 | ........ | ....... |
| 8 | 20 | Breech ... | 1 | Outside.. | 51,000 | .001833 | 98,000 | 17.00 | 40.28 | ........ | ....... |
| 8 | 20 | ....do..... | 2 | Middle .. | 49,000 | .001633 | 96,440 | 19.70 | 44.60 | ........ | ....... |
| 8 | 20 | ....do..... | 3 | Inside ... | 49,000 | .001683 | 96,800 | 19.50 | 41.91 | ........ | ....... |
| 8 | 20 | ....do..... | 4 | Middle .. | 46,000 | .001667 | 96,800 | 20.67 | 36.94 | 7.8566 | 19.49 |
| 8 | *21 | Muzzle... | 1 | Outside.. | 52,000 | .......... | 100,800 | 17.33 | 40.00 | ........ | ....... |
| 8 | *21 | ....do..... | 2 | Middle .. | 49,000 | .......... | 98,800 | 11.50 | 14.64 | ........ | ....... |
| 8 | *21 | ....do..... | 3 | ....do .... | 50,000 | .......... | 98,800 | 18.50 | 38.90 | ........ | ....... |
| 8 | *21 | ....do..... | 4 | Inside ... | 55,000 | .......... | 104,000 | 17.17 | 40.00 | ........ | ....... |
| 8 | *21 | Breech ... | 1 | Outside.. | 52,000 | .......... | 100,000 | 20.00 | 44.85 | ........ | ....... |
| 8 | *21 | ....do..... | 2 | Middle .. | 49,000 | .......... | 98,000 | 18.50 | 35.82 | ........ | ....... |
| 8 | *21 | ....do..... | 3 | Inside ... | 55,000 | .......... | 102,000 | 18.67 | 44.85 | ........ | ....... |
| 8 | *21 | ....do..... | 4 | Middle .. | 49,000 | .......... | 96,800 | 19.33 | 40.55 | ........ | ....... |
| 8 | †21 | Muzzle... | 5 | Outside.. | 50,000 | .......... | 96,000 | 17.00 | 22.71 | ........ | ....... |
| 8 | †21 | ....do..... | 6 | Middle... | —44,000 | .......... | 92,800 | 18.33 | 35.82 | ........ | ....... |
| 8 | †21 | ....do..... | 7 | Inside ... | 50,000 | .......... | 97,200 | 20.00 | 43.52 | ........ | ....... |
| 8 | †21 | ....do..... | 8 | Middle... | 46,000 | .......... | 93,600 | 21.67 | 41.64 | ........ | ....... |
| 8 | †21 | Breech ... | 5 | Outside.. | 50,000 | .......... | 96,000 | 21.00 | 47.96 | ........ | ....... |
| 8 | †21 | ....do..... | 6 | Middle... | —44,000 | .......... | 91,600 | 20.33 | 38.07 | ........ | ....... |
| 8 | †21 | ....do..... | 7 | Inside ... | 50,000 | .......... | 98,000 | 16.67 | 26.41 | ........ | ....... |
| 8 | †21 | ....do..... | 8 | Middle... | —44,000 | .......... | 92,000 | 22.00 | 41.91 | ........ | ....... |
| 8 | 21 | Muzzle... | 9 | Outside.. | 54,000 | .001917 | 97,200 | 20.67 | 45.11 | ........ | ....... |
| 8 | 21 | ....do..... | 10 | Middle... | 47,000 | .001683 | 94,400 | 19.67 | 36.94 | ........ | ....... |
| 8 | 21 | ....do..... | 11 | Inside ... | 54,000 | .001917 | 99,600 | 18.67 | 47.45 | ........ | ....... |
| 8 | 21 | ....do..... | 12 | Middle... | 52,000 | .001883 | 97,600 | 18.67 | 40.55 | ........ | ....... |

* Not accepted on these results; reannealed.

† Not accepted on these results; retempered and annealed.

*Results of tensile tests of tangential specimens from ends of jackets for 8-inch, 10-inch, and 12-inch B. L. rifles*—Continued.

| Caliber. | Number of jacket. | Breech or muzzle. | Number of specimen. | Position of specimen. | Elastic limit per square inch of original section. | Elongation per inch under strain at elastic limit. | Tensile strength per square inch of original section. | Elongation after rupture. | Reduction in area after rupture. | Specific gravity. | Hardness. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Pounds.* | *Inch.* | *Pounds.* | *Per ct.* | *Per ct.* | | |
| 8 | 21 | Breech ... | 9 | Middle... | 50,000 | .001850 | 98,400 | 19.17 | 43.79 | | |
| 8 | 21 | ....do..... | 10 | ....do .... | 51,000 | .001833 | 97,200 | 19.00 | 38.07 | 7.8558 | 20.81 |
| 8 | 21 | ....do..... | 11 | Inside ... | 53,000 | .001850 | 100,000 | 17.67 | 45.11 | | |
| 8 | 21 | ....do..... | 12 | Outside.. | 51,000 | .001600 | 96,400 | 19.00 | 40.55 | | |
| 8 | *22 | Muzzle... | 1 | Middle... | 54,000 | .001967 | 97,200 | 17.00 | 41.64 | | |
| 8 | *22 | ....do..... | 2 | Inside ... | 57,000 | .002067 | 99,600 | 11.00 | 11.32 | | |
| 8 | *22 | ....do..... | 3 | Middle... | 51,000 | .001867 | 96,400 | 18.33 | 28.82 | | |
| 8 | *22 | ....do..... | 4 | Outside.. | 54,000 | .002017 | 96,000 | 20.83 | 49.48 | | |
| 8 | 22 | ....do..... | 5 | Inside ... | 58,000 | .002117 | 100,000 | 17.67 | 31.49 | | |
| 8 | 22 | ....do..... | 6 | Middle... | 48,000 | .001883 | 96,000 | 20.50 | 38.35 | | |
| 8 | 22 | ....do..... | 7 | Outside.. | 55,000 | .001900 | 96,000 | 19.67 | 47.96 | | |
| 8 | 22 | ....do..... | 8 | Middle... | 48,000 | .001817 | 96,800 | 17.00 | 39.73 | | |
| 8 | 22 | Breech ... | 1 | ....do .... | 48,000 | .001767 | 94,800 | 20.67 | 44.05 | | |
| 8 | 22 | ....do..... | 2 | Inside ... | 50,000 | .001733 | 94,000 | 17.67 | 41.10 | | |
| 8 | 22 | ....do..... | 3 | Middle... | 48,000 | .001733 | 96,000 | 19.83 | 43.25 | 7.8574 | 19.60 |
| 8 | 22 | ....do..... | 4 | Outside.. | 53,000 | .002100 | 99,200 | 16.67 | 40.28 | | |
| 8 | 23 | Muzzle... | 1 | Inside ... | 54,000 | .001967 | 103,600 | 17.83 | 35.53 | | |
| 8 | 23 | ....do..... | 2 | Outside.. | 54,000 | .001933 | 100,000 | 19.33 | 42.72 | | |
| 8 | 23 | ....do..... | 3 | Middle... | 50,000 | .001733 | 98,880 | 18.70 | 39.20 | | |
| 8 | 23 | ....do..... | 4 | ....do .... | 51,000 | .001817 | 102,000 | 19.33 | 37.79 | | |
| 8 | *23 | Breech ... | 1 | Outside.. | 54,000 | .001867 | 98,800 | 19.50 | 38.62 | | |
| 8 | *23 | ....do..... | 2 | Middle... | 48,000 | .001700 | 96,080 | 15.70 | 18.30 | | |
| 8 | *23 | ....do..... | 3 | ....do .... | 47,000 | .001700 | 98,400 | 18.00 | 36.94 | | |
| 8 | *23 | ....do..... | 4 | Inside ... | 55,000 | .001883 | 102,000 | 16.67 | 30.60 | | |
| 8 | 23 | ....do..... | 5 | ....do .... | 50,000 | .001750 | 102,400 | 16.00 | 36.38 | | |
| 8 | 23 | ....do..... | 6 | Middle... | 46,000 | .001650 | 96,400 | 18.00 | 37.23 | | |
| 8 | 23 | ....do..... | 7 | Outside.. | 49,000 | .001717 | 96,800 | 19.33 | 43.79 | | |
| 8 | 23 | ....do..... | 8 | Middle... | 45,000 | .001733 | 96,400 | 18.00 | 38.35 | 7.8570 | 20.70 |
| 8 | †24 | Muzzle... | 1 | Inside ... | 54,000 | | 89,200 | 19.20 | 48.47 | | |
| 8 | †24 | ....do..... | 2 | Middle... | −40,000 | | 89,400 | 18.60 | 39.73 | | |
| 8 | †24 | ....do..... | 3 | Outside.. | 51,000 | | 82,800 | 19.17 | 42.99 | | |
| 8 | †24 | ....do..... | 4 | Middle... | 40,000 | | 87,600 | 22.27 | 45.63 | | |
| 8 | †24 | Breech ... | 1 | Inside ... | 44,000 | | 85,600 | 22.93 | 49.23 | | |
| 8 | †24 | ....do..... | 2 | Middle... | −40,000 | | 78,800 | 25.60 | 47.45 | | |
| 8 | †24 | ....do..... | 3 | Outside.. | 47,000 | | 90,200 | 18.00 | 32.07 | | |
| 8 | †24 | ....do..... | 4 | Middle... | −40,000 | | 86,000 | 22.57 | 44.85 | | |
| 8 | †24 | Muzzle... | 5 | ....do .... | 46,000 | | 95,200 | 17.17 | 39.18 | | |
| 8 | †24 | ....do..... | 6 | Outside.. | 52,000 | | 97,600 | 17.83 | 38.35 | | |
| 8 | †24 | ....do..... | 7 | Middle... | 46,000 | | 93,200 | 18.67 | 39.73 | | |
| 8 | †24 | ....do..... | 8 | Inside ... | 47,000 | | 95,600 | 16.67 | 29.42 | | |
| 8 | †24 | Breech ... | 5 | Outside.. | 46,000 | | 93,600 | 15.83 | 35.82 | | |
| 8 | †24 | ....do..... | 6 | Middle... | −40,000 | | 82,400 | 22.67 | 46.41 | | |
| 8 | †24 | ....do..... | 7 | Inside ... | −44,000 | | 83,600 | 24.33 | 49.73 | | |
| 8 | †24 | ....do..... | 8 | Middle... | −40,000 | | 82,800 | 23.33 | 45.63 | | |
| 8 | 24 | Muzzle... | 9 | Middle .. | −44,000 | | 86,800 | 22.83 | 42.99 | | |
| 8 | 24 | ....do..... | 10 | Outside.. | 46,000 | .001650 | 90,000 | 21.67 | 28.82 | | |
| 8 | 24 | ....do..... | 11 | Middle .. | 49,000 | .001700 | 86,120 | 21.00 | 41.90 | | |
| 8 | 24 | ....do..... | 12 | Inside ... | 45,000 | .001450 | 88,400 | 21.50 | 38.35 | | |
| 8 | 24 | Breech ... | 9 | Middle .. | 44,000 | .001533 | 86,320 | 21.70 | 47.20 | | |
| 8 | 24 | ....do..... | 10 | Outside.. | 51,000 | .001667 | 96,800 | 15.33 | 34.39 | | |
| 8 | 24 | ....do..... | 11 | Middle .. | −44,000 | .000000 | 80,800 | 24.83 | 48.72 | | |
| 8 | 24 | ....do..... | 12 | Inside ... | −44,000 | .000000 | 82,000 | 23.50 | 49.73 | | |
| 10 | ‡2 | Muzzle... | 1 | ....do .... | 56,000 | | 100,000 | 18.17 | 49.99 | | |
| 10 | ‡2 | ....do..... | 2 | Middle .. | 51,000 | | 97,600 | 16.33 | 30.60 | | |
| 10 | ‡2 | ....do..... | 3 | Outside.. | 51,000 | | 99,600 | 18.00 | 44.85 | | |
| 10 | ‡2 | ....do..... | 4 | Middle .. | 51,000 | | 96,800 | 18.33 | 45.63 | | |
| 10 | ‡2 | Breech ... | 1 | ....do .... | 52,000 | | 102,800 | 13.83 | 20.82 | | |
| 10 | ‡2 | ....do..... | 2 | Inside ... | 56,000 | | 103,600 | 12.50 | 24.88 | | |
| 10 | ‡2 | ....do..... | 3 | Middle . | 51,000 | | 101,600 | 15.83 | 21.15 | | |
| 10 | ‡2 | ....do..... | 4 | Outside.. | 56,000 | | 100,400 | 19.33 | 49.23 | | |
| 10 | 2 | Muzzle... | 5 | ....do .... | 54,000 | .001867 | 96,400 | 20.33 | 45.37 | | |
| 10 | 2 | ....do..... | 6 | Middle .. | 45,000 | .001583 | 92,000 | 19.67 | 44.58 | | |
| 10 | 2 | ....do..... | 7 | Inside ... | 52,000 | .001817 | 95,200 | 19.67 | 49.73 | | |
| 10 | 2 | ....do..... | 8 | Middle .. | 45,000 | .001567 | 92,000 | 19.67 | 41.91 | | |
| 10 | 2 | Breech ... | 5 | Outside.. | 54,000 | .001850 | 96,400 | 20.00 | 48.22 | | |
| 10 | 2 | ....do..... | 6 | Middle .. | 44,000 | .001617 | 92,800 | 19.00 | 41.37 | | |

* Not accepted on these results; retested.
† Not accepted on these results; retempered and annealed.
‡ Not accepted on these results; reannealed.

*Results of tensile tests of tangential specimens from ends of jackets for 8-inch, 10-inch, and 12-inch B. L. rifles*—Continued.

| Caliber. | Number of jacket. | Breech or muzzle. | Number of specimen. | Position of specimen. | Elastic limit per square inch of original section. | Elongation per inch under strain at elastic limit. | Tensile strength per square inch of original section. | Elongation after rupture. | Reduction in area after rupture. | Specific gravity. | Hardness. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Pounds.* | *Inch.* | *Pounds.* | *Per ct.* | *Per ct.* | | |
| 10 | 2 | Breech ... | 7 | Inside ... | 51,000 | .001783 | 98,000 | 15.33 | 27.62 | ........ | ....... |
| 10 | 2 | ....do..... | 8 | Middle .. | 46,000 | .001683 | 95,200 | 17.67 | 31.78 | 7.8570 | 19.08 |
| 12 | 3 | Muzzle... | 1 | Outside.. | 52,000 | .001833 | 98,400 | 20.83 | 43.79 | ........ | ....... |
| 12 | 3 | ....do..... | 2 | Middle .. | 49,000 | .001750 | 97,600 | 17.17 | 40.28 | ........ | ....... |
| 12 | 3 | ....do..... | 3 | Inside ... | 57,000 | .001967 | 100,000 | 16.50 | 37.51 | ........ | ....... |
| 12 | 3 | ....do..... | 4 | Middle .. | 47,000 | .001667 | 98,000 | 16.00 | 41.37 | ........ | ....... |
| 12 | 3 | Breech ... | 1 | ....do .... | 49,000 | .001717 | 96,800 | 19.33 | 37.51 | ........ | ....... |
| 12 | 3 | ....do..... | 2 | Outside.. | 50,000 | .001717 | 93,600 | 21.67 | 47.19 | ........ | ....... |
| 12 | 3 | ....do..... | 3 | Middle .. | 48,000 | .001667 | 98,000 | 18.17 | 33.23 | 7.8542 | 18.58 |
| 12 | 3 | ....do..... | 4 | Inside ... | 55,000 | .001917 | 103,200 | 15.33 | 30.01 | ........ | ....... |

*Results of compression tests of tangential specimens from the breech end of jackets for 8-inch, 10-inch, and 12-inch B. L. rifles.*

[Length of specimen, 5 inches; sectional area, 1 square inch.]

| Caliber. | Number of jacket. | Number of specimen. | Elastic limit per square inch of original section. | Ultimate strength per square inch of original section. |
|---|---|---|---|---|
| | | | *Pounds.* | *Pounds,* |
| 8 | 2 | 17 | 51,000 | 108,330 |
| 8 | 9 | 9 | 44,000 | 88,200 |
| 8 | 10 | 13 | 48,000 | 103,100 |
| 8 | 11 | 5 | 50,000 | 103,600 |
| 8 | 12 | 9 | 52,000 | 94,200 |
| 8 | 13 | 5 | 50,000 | 107,800 |
| 8 | 14 | 5 | 47,000 | 81,200 |
| 8 | 15 | 5 | 52,000 | 110,350 |
| 8 | 16 | 5 | 49,000 | 99,100 |
| 8 | 17 | 5 | 51,000 | 110,300 |
| 8 | 18 | 5 | 49,000 | 106,700 |
| 8 | 19 | 5 | 52,000 | 102,820 |
| 8 | 20 | 5 | 49,000 | 107,780 |
| 8 | 21 | 13 | 51,000 | 110,300 |
| 8 | 22 | 5 | 51,000 | 109,980 |
| 8 | 23 | 5 | 51,000 | 111,550 |
| 8 | 24 | ........... | ............ | ............ |
| 10 | 2 | 9 | 48,000 | 106,700 |
| 12 | 3 | 5 | 45,000 | 109,300 |

*Results of tensile tests of tangential specimens from trunnion hoops for 8-inch, 10-inch, and 12-inch B. L. rifles.*

**[Length of specimen, 4 inches; sectional area, 0.25 square inch.]**

| Caliber. | Number of hoop. | Number of specimen. | Position of specimen. | Elastic limit per square inch of original section. | Elongation per inch under strain at elastic limit. | Tensile strength per square inch of original section. | Elongation after rupture. | Reduction in area after rupture. |
|---|---|---|---|---|---|---|---|---|
| | | | | *Pounds.* | *Inch.* | *Pounds.* | *Per cent.* | *Per cent.* |
| 8 | *2 | 1 | Outside | —48,000 | ............ | 100,000 | 13.875 | 29.12 |
| 8 | *2 | 2 | Middle | 50,000 | ............ | 92,400 | 14.125 | 24.57 |
| 8 | *2 | 3 | Inside | 52,000 | ............ | 100,200 | 14.50 | 32.94 |
| 8 | *2 | 4 | Middle | 50,000 | ............ | 101,200 | 15.00 | 26.10 |
| 8 | 2 | 4 | Outside | 50,000 | .0017875 | 94,800 | 17.50 | 40.55 |
| 8 | 2 | 5 | Middle | —48,000 | .0000000 | 94,800 | 15.50 | 36.94 |
| 8 | 2 | 6 | ....do | 48,000 | .0017750 | 93,600 | 16.50 | 40.28 |
| 8 | 2 | 7 | Inside | 50,000 | .0017875 | 97,200 | 15.50 | 36.94 |
| 8 | 5 | 1 | ....do | 58,000 | .0020125 | 108,000 | 17.25 | 41.64 |
| 8 | 5 | 2 | Middle | 53,000 | .0018250 | 109,600 | 15.75 | 39.18 |
| 8 | 5 | 3 | Outside | 60,000 | .0020500 | 110,400 | 15.25 | 40.83 |
| 8 | 5 | 4 | Middle | 55,000 | .0019000 | 106,400 | 17.50 | 43.25 |
| 8 | 8 | 1 | Outside | 58,000 | .0019750 | 108,800 | 15.75 | 44.58 |
| 8 | 8 | 2 | Inside | 57,000 | .0019875 | 105,200 | 12.50 | 29.71 |
| 8 | 8 | 3 | Middle | 55,000 | .0019125 | 104,800 | 17.25 | 43.25 |
| 8 | 8 | 4 | ....do | 53,000 | .0018625 | 99,600 | 16.625 | 43.52 |
| 8 | 9 | 1 | Outside | 56,000 | .0018875 | 104,000 | 17.625 | 46.67 |
| 8 | 9 | 2 | Middle | 48,000 | .0016500 | 96,800 | 19.50 | 45.89 |
| 8 | 9 | 3 | ....do | 50,000 | .0017000 | 100,800 | 19.00 | 45.11 |
| 8 | 9 | 4 | Inside | 50,000 | .0016750 | 101,200 | 18.375 | 46.15 |
| 8 | 10 | 1 | Outside | 57,000 | .0019750 | 105,600 | 16.25 | 45.37 |
| 8 | 10 | 2 | Middle | 53,000 | .0017625 | 113,200 | 16.75 | 38.35 |
| 8 | 10 | 3 | ....do | 53,000 | .0017875 | 102,000 | 17.00 | 45.37 |
| 8 | 10 | 4 | Inside | 58,000 | .0020125 | 105,600 | 15.00 | 47.96 |
| 8 | 12 | 1 | Outside | 53,000 | .0018500 | 101,200 | 14.75 | 39.73 |
| 8 | 12 | 2 | Middle | 53,000 | .0018625 | 100,400 | 14.00 | 24.57 |
| 8 | 12 | 3 | ....do | 54,000 | .0018500 | 102,000 | 17.00 | 41.91 |
| 8 | 12 | 4 | Inside | 56,000 | .0019625 | 105,600 | 16.25 | 43.25 |
| 8 | 13 | 1 | Middle | 53,000 | .0018375 | 100,000 | 16.625 | 31.49 |
| 8 | 13 | 2 | ....do | 52,000 | .0018125 | 98,400 | 17.50 | 38.07 |
| 8 | 13 | 3 | Outside | 53,000 | .0018625 | 104,000 | 16.25 | 36.10 |
| 8 | 13 | 4 | Inside | 56,000 | .0019125 | 104,800 | 15.25 | 42.99 |
| 8 | *14 | 1 | Outside | 49,000 | ............ | 95,200 | 17.25 | 52.71 |
| 8 | *14 | 2 | Middle | 50,000 | ............ | 101,200 | 14.875 | 36.67 |
| 8 | *14 | 3 | ....do | —48,000 | ............ | 91,200 | 16.00 | 42.45 |
| 8 | *14 | 4 | Inside | 53,000 | ............ | 98,800 | 16.75 | 46.15 |
| 8 | 14 | 5 | Middle | 53,000 | .0018375 | 107,000 | 13.875 | 36.10 |
| 8 | 14 | 6 | ....do | 50,000 | .0018125 | 98,400 | 15.625 | 31.49 |
| 8 | 14 | 7 | Inside | 55,000 | .0018500 | 104,200 | 13.875 | 44.58 |
| 8 | 14 | 8 | Outside | 55,000 | .0019375 | 107,200 | 14.25 | 36.67 |
| 8 | 15 | 1 | Outside | 55,000 | .0019500 | 105,600 | 14.75 | 41.10 |
| 8 | 15 | 2 | Middle | 50,000 | .0017750 | 99,200 | 13.75 | 34.10 |
| 8 | 15 | 3 | ....do | 51,000 | .0017625 | 101,200 | 16.75 | 34.96 |
| 8 | 15 | 4 | Inside | 54,000 | .0018000 | 104,400 | 15.00 | 45.89 |
| 8 | 16 | 1 | Outside | 55,000 | .0019625 | 105,200 | 16.50 | 38.90 |
| 8 | 16 | 2 | Middle | 52,000 | .0017250 | 100,000 | 16.125 | 36.10 |
| 8 | 16 | 3 | ....do | 54,000 | .0018625 | 102,400 | 16.125 | 43.52 |
| 8 | 16 | 4 | Inside | 53,000 | .0018000 | 100,000 | 15.25 | 38.23 |
| 8 | 17 | 1 | Outside | 54,000 | .0018500 | 102,000 | 15.50 | 31.49 |
| 8 | 17 | 2 | Inside | 52,000 | .0017750 | 100,000 | 16.50 | 33.52 |
| 8 | 17 | 3 | Middle | 52,000 | .0018250 | 102,000 | 15.75 | 32.07 |
| 8 | 17 | 4 | ....do | 52,000 | .0018875 | 98,800 | 15.875 | 30.60 |
| 8 | 18 | 1 | Outside | 52,000 | .0017375 | 102,400 | 15.00 | 37.51 |
| 8 | 18 | 2 | Middle | 51,000 | .0018250 | 101,600 | 15.875 | 39.18 |
| 8 | 18 | 3 | ....do | 51,000 | .0017875 | 101,200 | 16.00 | 39.73 |
| 8 | 18 | 4 | Inside | 54,000 | .0019250 | 101,600 | 14.75 | 37.23 |
| 8 | *19 | 1 | Outside | 54,000 | ............ | 101,200 | 17.25 | 45.63 |
| 8 | *19 | 2 | Inside | 51,000 | ............ | 98,000 | 16.00 | 40.83 |
| 8 | *19 | 3 | Middle | 49,000 | ............ | 96,400 | 17.75 | 43.26 |
| 8 | *19 | 4 | ....do | —48,000 | ............ | 96,000 | 16.75 | 35.25 |
| 8 | 19 | 5 | ....do | —48,000 | .0000000 | 96,000 | 15.625 | 45.11 |
| 8 | 19 | 6 | ....do | 50,000 | .0017000 | 104,400 | 13.00 | 35.53 |
| 8 | 19 | 7 | Outside | 58,000 | .0020375 | 108,400 | 14.875 | 39.45 |
| 8 | 19 | 8 | Inside | 51,000 | .0017500 | 104,000 | 13.50 | 43.38 |

* Not accepted on these results; retempered and annealed.

*Results of tensile tests of tangential specimens from trunnion hoops for 8-inch, 10-inch, and 12-inch B. L. rifles*—Continued.

| Caliber. | Number of hoop. | Number of specimen. | Position of specimen. | Elastic limit per square inch of original section. | Elongation per inch under strain at elastic limit. | Tensile strength per square inch of original section. | Elongation after rupture. | Reduction in area after rupture. |
|---|---|---|---|---|---|---|---|---|
| | | | | *Pounds.* | *Inch.* | *Pounds.* | *Per cent.* | *Per cent.* |
| 8 | 20 | 1 | Outside | 52,000 | .0019250 | 104,000 | 15.25 | 40.00 |
| 8 | 20 | 2 | Inside | 54,000 | .0018500 | 102,800 | 17.75 | 43.25 |
| 8 | 20 | 3 | Middle | 51,000 | .0017375 | 100,800 | 15.75 | 41.10 |
| 8 | 20 | 4 | ....do | 51,000 | .0018000 | 100,800 | 14.00 | 31.78 |
| 8 | 21 | 1 | Outside | 54,000 | .0017625 | 102,400 | 15.50 | 36.38 |
| 8 | 21 | 2 | Inside | 53,000 | .0017750 | 94,800 | 19.25 | 47.19 |
| 8 | 21 | 3 | Middle | 51,000 | .0017000 | 98,000 | 17.50 | 37.79 |
| 8 | 21 | 4 | ....do | 51,000 | .0016875 | 98,800 | 16.25 | 42.72 |
| 8 | 22 | 1 | Outside | 57,000 | .0021375 | 105,200 | 14.625 | 40.00 |
| 8 | 22 | 2 | Middle | 54,000 | .0018000 | 106,400 | 15.00 | 32.36 |
| 8 | 22 | 3 | ....do | 57,000 | .0019250 | 106,000 | 17.00 | 36.67 |
| 8 | 22 | 4 | Inside | 58,000 | .0020125 | 110,000 | 15.75 | 33.23 |
| 8 | 23 | 1 | Outside | 56,000 | .0019125 | 108,000 | 16.25 | 40.55 |
| 8 | 23 | 2 | Middle | 57,000 | .0020000 | 106,800 | 15.25* | 36.67 |
| 8 | 23 | 3 | ....do | 57,000 | .0019875 | 108,000 | 15.75 | 34.96 |
| 8 | 23 | 4 | Inside | 55,000 | .0015875 | 110,400 | 16.00 | 39.18 |
| 8 | 24 | 1 | Outside | 53,000 | .0018500 | 103,200 | 16.125 | 37.23 |
| 8 | 24 | 2 | Middle | 52,000 | .0017875 | 102,000 | 13.00 | 17.56 |
| 8 | 24 | 3 | ....do | 53,000 | .0017500 | 99,600 | 17.00 | 29.12 |
| 8 | 24 | 4 | Inside | 54,000 | .0018375 | 102,800 | 15.875 | 36.94 |
| 10 | 2 | 1 | Outside | 56,000 | .0020000 | 106,400 | 14.50 | 40.83 |
| 10 | 2 | 2 | Inside | 55,000 | .0018875 | 100,800 | 19.75 | 44.58 |
| 10 | 2 | 3 | Middle | 56,000 | .0019625 | 105,200 | 16.75 | 41.64 |
| 10 | 2 | 4 | ....do | ............ | ............ | 98,400 | 17.00 | 39.18 |
| 10 | 2 | 5 | ....do | 49,000 | ............ | 94,400 | 16.50 | 32.94 |
| 10 | 3 | 1 | Outside | 58,000 | .0019875 | 110,800 | 15.625 | 45.63 |
| 10 | 3 | 2 | Middle | 57,000 | .0018875 | 108,400 | 13.125 | 34.10 |
| 10 | 3 | 3 | ....do | 57,000 | .0019875 | 109,600 | 15.25 | 36.10 |
| 10 | 3 | 4 | Inside | 60,000 | .0020875 | 110,400 | 14.25 | 38.35 |
| 10 | 4 | 1 | Outside | 58,000 | .0020000 | 106,800 | 17.00 | 43.25 |
| 10 | 4 | 2 | Middle | 54,000 | .0018375 | 104,000 | 13.875 | 25.11 |
| 10 | 4 | 3 | ....do | 54,000 | .0018250 | 104,000 | 17.375 | 44.58 |
| 10 | 4 | 4 | Inside | 59,000 | .0019750 | 106,800 | 14.75 | 37.23 |
| 10 | 5 | 1 | Outside | 58,000 | .0020000 | 106,800 | 17.00 | 42.72 |
| 10 | 5 | 2 | Inside | 61,000 | .0021250 | 106,800 | 16.625 | 48.22 |
| 10 | 5 | 3 | Middle | 52,000 | .0017750 | 101,200 | 17.375 | 40.28 |
| 10 | 5 | 4 | ....do | 53,000 | .0018000 | 101,200 | 14.50 | 34.68 |
| 12 | *2 | 1 | ....do | 56,000 | ............ | 108,400 | 14.50 | 28.52 |
| 12 | *2 | 2 | ....do | 55,000 | ............ | 106,800 | 10.75 | 13.00 |
| 12 | *2 | 3 | Inside | 56,000 | ............ | 110,800 | 14.75 | 32.65 |
| 12 | *2 | 4 | Outside | 58,000 | ............ | 108,400 | 14.25 | 29.12 |
| 12 | 2 | 5 | Middle | 56,000 | .0019625 | 105,600 | 14.50 | 30.90 |
| 12 | 2 | 6 | Inside | 58,000 | .0019500 | 108,000 | 14.25 | 35.82 |
| 12 | 2 | 7 | Outside | 50,000 | .0016500 | 102,400 | 12.50 | 30.01 |
| 12 | 2 | 8 | Middle | 57,000 | .0018750 | 106,400 | 14.25 | 33.23 |

* Not accepted on these results; reannealed.

### *sults of tensile tests of tangential specimens from hoops for 8-inch, 10-inch, and 12-inch B. L. rifles.*

[Length of specimen, 4 inches; sectional area, 0.25 square inch.]

| Caliber. | Number of gun. | Mark of hoop. | Breech or muzzle. | Number of specimen. | Position of specimen. | Elastic limit per square inch of original section. | Elongation per inch under strain at elastic limit. | Tensile strength per square inch of original section. | Elongation after rupture. | Reduction of area after rupture. | Specific gravity. | Hardness. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Pounds.* | *Inch.* | *Pounds.* | *Per ct.* | *Per ct.* | | |
| 8 | 3 | $A_1$ | .......... | 1 | Outside. | 58,000 | .0020000 | 101,200 | 17.50 | 45.37 | ........ | ........ |
| 8 | 3 | $A_1$ | .......... | 2 | Middle.. | 55,000 | .0019125 | 103,200 | 17.50 | 37.51 | ........ | ........ |
| 8 | 3 | $A_1$ | .......... | 3 | Inside .. | 55,000 | .0018750 | 104,800 | 14.75 | 45.63 | ........ | ........ |
| 8 | 6 | $A_1$ | .......... | 1 | Outside. | 59,000 | .0020875 | 107,600 | 13.75 | 39.18 | ........ | ........ |
| 8 | 6 | $A_1$ | .......... | 2 | Inside .. | 59,000 | .0020750 | 105,200 | 15.25 | 43.52 | ........ | ........ |
| 8 | 6 | $A_1$ | .......... | 3 | Middle.. | 55,000 | .0019375 | 105,000 | 14.50 | 36.10 | ........ | ........ |
| 8 | 7 | $A_1$ | .......... | 1 | Inside .. | 59,000 | .0020125 | 106,000 | 18.00 | 46.67 | ........ | ........ |
| 8 | 7 | $A_1$ | .......... | 2 | Middle.. | 58,000 | .0020500 | 104,000 | 15.00 | 41.91 | ........ | ........ |
| 8 | 7 | $A_1$ | .......... | 3 | Outside. | 62,000 | .0021375 | 108,000 | 16.00 | 44.58 | ........ | ........ |
| 8 | 12 | $A_1$ | .......... | 1 | Inside .. | 63,000 | .0022000 | 113,600 | 15.75 | 34.39 | ........ | ........ |
| 8 | 12 | $A_1$ | .......... | 2 | Middle.. | 58,000 | .0020625 | 102,800 | 18.25 | 45.63 | ........ | ........ |
| 8 | 12 | $A_1$ | .......... | 3 | Outside. | 59,000 | .0020750 | 102,000 | 18.375 | 45.11 | ........ | ........ |
| 8 | 13 | $A_1$ | .......... | 1 | ....do ... | 56,000 | .0019500 | 106,800 | 17.25 | 39.45 | ........ | ........ |
| 8 | 13 | $A_1$ | .......... | 2 | Middle.. | 52,000 | .0018250 | 103,600 | 18.125 | 39.45 | ........ | ........ |
| 8 | 13 | $A_1$ | .......... | 3 | Inside .. | 57,000 | .0019375 | 106,000 | 13.50 | 36.67 | ........ | ........ |
| 8 | 15 | $A_1$ | .......... | 1 | Outside. | 55,000 | .0018625 | 98,800 | 16.50 | 44.85 | ........ | ........ |
| 8 | 15 | $A_1$ | .......... | 2 | Inside .. | 56,000 | .0019250 | 103,600 | 13.75 | 34.68 | ........ | ........ |
| 8 | 15 | $A_1$ | .......... | 3 | Middle.. | 52,000 | .0017875 | 100,000 | 15.875 | 39.45 | ........ | ........ |
| 8 | 16 | $A_1$ | .......... | 1 | Outside. | 66,000 | .0023250 | 113,200 | 14.75 | 40.28 | ........ | ........ |
| 8 | 16 | $A_1$ | .......... | 2 | Middle.. | 60,000 | .0020000 | 112,800 | 15.25 | 38.90 | ........ | ........ |
| 8 | 16 | $A_1$ | .......... | 3 | Inside .. | 67,000 | .0023625 | 116,000 | 14.875 | 36.67 | ........ | ........ |
| 8 | 18 | $A_1$ | .......... | 1 | Outside. | 64,000 | .0022750 | 112,000 | 12.25 | 35.82 | ........ | ........ |
| 8 | 18 | $A_1$ | .......... | 2 | Middle.. | 60,000 | .0021250 | 112,000 | 12.375 | 35.82 | ........ | ........ |
| 8 | 18 | $A_1$ | .......... | 3 | Inside .. | 65,000 | .0023875 | 112,400 | 14.75 | 42.72 | ........ | ........ |
| 8 | 19 | $A_1$ | .......... | 1 | Outside. | 63,000 | .0021500 | 110,000 | 15.50 | 42.45 | ........ | ........ |
| 8 | 19 | $A_1$ | .......... | 2 | Middle.. | 58,000 | .0019875 | 110,000 | 18.375 | 45.89 | ........ | ........ |
| 8 | 19 | $A_1$ | .......... | 3 | Inside .. | 63,000 | .0021125 | 108,800 | 18.25 | 43.52 | ........ | ........ |
| 8 | 22 | $A_1$ | .......... | 1 | Outside. | 62,000 | .0021625 | 106,400 | 19.25 | 44.58 | ........ | ........ |
| 8 | 22 | $A_1$ | .......... | 2 | Middle.. | 61,000 | .0020875 | 108,000 | 17.125 | 39.18 | ........ | ........ |
| 8 | 22 | $A_1$ | .......... | 3 | Inside .. | 64,000 | .0021875 | 107,600 | 18.125 | 43.25 | ........ | ........ |
| 8 | 24 | $A_1$ | .......... | 1 | Outside. | 65,000 | .0023125 | 113,200 | 16.25 | 39.18 | ........ | ........ |
| 8 | 24 | $A_1$ | .......... | 2 | Middle.. | 60,000 | .0021250 | 112,000 | 16.875 | 40.55 | ........ | ........ |
| 8 | 24 | $A_1$ | .......... | 3 | Inside .. | 64,000 | .0022000 | 113,600 | 17.125 | 44.05 | ........ | ........ |
| 10 | 2 | $A_1$ | Muzzle . | 1 | Outside. | 64,000 | .0023625 | 116,000 | 14.75 | 36.38 | ........ | ........ |
| 10 | 2 | $A_1$ | ....do ... | 2 | Inside .. | 65,000 | .0022750 | 118,800 | 12.75 | 36.67 | ........ | ........ |
| 10 | 2 | $A_1$ | ....do ... | 3 | Middle.. | 57,000 | .0020500 | 112,800 | 13.25 | 34.39 | ........ | ........ |
| 10 | 2 | $A_1$ | Breech.. | 1 | Outside. | 64,000 | .0022125 | 117,200 | 15.50 | 32.07 | ........ | ........ |
| 10 | 2 | $A_1$ | ....do ... | 2 | Middle.. | 61,000 | .0022000 | 114,400 | 15.50 | 37.23 | ........ | ........ |
| 10 | 2 | $A_1$ | ....do ... | 3 | Inside .. | 63,000 | .0022125 | 115,200 | 13.25 | 30.31 | ........ | ........ |
| 10 | 2 | $A_2$ | .......... | 1 | Outside. | 56,000 | .0019500 | 106,400 | 17.25 | 39.73 | ........ | ........ |
| 10 | 2 | $A_2$ | .......... | 2 | Middle . | 53,000 | .0018500 | 104,000 | 16.75 | 43.25 | ........ | ........ |
| 10 | 2 | $A_2$ | .......... | 3 | Inside .. | 56,000 | .0019500 | 104,800 | 14.50 | 36.94 | 7.8554 | 21.77 |
| 10 | 4 | $A_2$ | .......... | 1 | Outside. | 66,000 | .0022750 | 116,400 | 14.00 | 34.96 | ........ | ........ |
| 10 | 4 | $A_2$ | .......... | 2 | Middle . | 63,000 | .0021875 | 112,400 | 14.25 | 40.00 | ........ | ........ |
| 10 | 4 | $A_2$ | .......... | 3 | Inside .. | 66,000 | .0022125 | 118,400 | 13.75 | 37.51 | ........ | ........ |
| 12 | 2 | $A_2$ | Muzzle . | 1 | Outside. | 57,000 | .0019875 | 106,400 | 16.375 | 43.52 | ........ | ........ |
| 12 | 2 | $A_2$ | ....do ... | 2 | Middle . | 54,000 | .0018750 | 104,800 | 17.50 | 41.37 | ........ | ........ |
| 12 | 2 | $A_2$ | ....do ... | 3 | Inside .. | 59,000 | .0020250 | 105,200 | 16.50 | 46.67 | ........ | ........ |
| 12 | 2 | $A_2$ | Breech.. | 1 | ....do ... | 57,000 | .0019125 | 104,000 | 17.875 | 47.96 | ........ | ........ |
| 12 | 2 | $A_2$ | ....do ... | 2 | Middle . | 55,000 | .0019125 | 102,400 | 17.50 | 41.91 | ........ | ........ |
| 12 | 2 | $A_2$ | ....do ... | 3 | Outside. | 57,000 | .0019625 | 103,200 | 17.50 | 46.93 | ........ | ........ |
| 12 | 3 | $A_2$ | Muzzle . | 1 | ....do ... | 62,000 | .0020750 | 107,200 | 18.125 | 48.72 | ........ | ........ |
| 12 | 3 | $A_2$ | ....do ... | 2 | Inside .. | 65,000 | .0021500 | 110,000 | 18.50 | 46.15 | ........ | ........ |
| 12 | 3 | $A_2$ | ....do ... | 3 | Middle . | 59,000 | .0019500 | 109,200 | 18.75 | 43.52 | ........ | ........ |
| 12 | 3 | $A_2$ | Breech.. | 1 | ....do ... | 58,000 | .0019875 | 109,200 | 15.375 | 45.63 | ........ | ........ |
| 12 | 3 | $A_2$ | ....do ... | 2 | Inside .. | 63,000 | .0021125 | 110,400 | 14.75 | 45.63 | ........ | ........ |
| 12 | 3 | $A_2$ | ....do ... | 3 | Outside. | 61,000 | .0021625 | 111,200 | 16.50 | 44.58 | ........ | ........ |
| 8 | 7 | $A_3$ | .......... | 1 | Inside .. | 53,000 | .0018250 | 102,000 | 15.75 | 39.18 | ........ | ........ |
| 8 | 7 | $A_3$ | .......... | 2 | Middle . | 52,000 | .0018250 | 100,800 | 16.00 | 38.90 | ........ | ........ |
| 8 | 7 | $A_3$ | .......... | 3 | Outside. | 58,000 | .0020375 | 105,600 | 15.00 | 40.83 | 7.8496 | 20.35 |
| 8 | 8 | $A_3$ | .......... | 1 | Inside .. | 57,000 | .0020125 | 105,600 | 14.875 | 37.51 | ........ | ........ |
| 8 | 8 | $A_3$ | .......... | 2 | Middle . | 53,000 | .0017625 | 100,800 | 16.75 | 43.79 | ........ | ........ |
| 8 | 8 | $A_3$ | .......... | 3 | Outside. | 57,000 | .0019750 | 105,600 | 17.125 | 42.18 | ........ | ........ |
| 8 | 10 | $A_3$ | .......... | 1 | ....do ... | 58,000 | .0019750 | 103,600 | 17.25 | 40.00 | ........ | ........ |
| 8 | 10 | $A_3$ | .......... | 2 | Middle . | 55,000 | .0018625 | 98,000 | 19.25 | 42.45 | ........ | ........ |
| 8 | 10 | $A_3$ | .......... | 3 | Inside .. | 54,000 | .0018875 | 98,400 | 15.875 | 42.72 | 7.8461 | 20.36 |

*Results of tensile tests of tangential specimens from hoops for 8-inch, 10-inch, and 12-inch B. L. rifles*—Continued.

| Caliber. | Number of gun. | Mark of hoop. | Breech or muzzle. | Number of specimen. | Position of specimen. | Elastic limit per square inch of original section. | Elongation per inch under strain at elastic limit. | Tensile strength per square inch of original section. | Elongation after rupture. | Reduction of area after rupture. | Specific gravity. | Hardness. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Pounds.* | *Inch.* | *Pounds.* | *Per ct.* | *Per ct.* | | |
| 8 | 15 | $A_3$ | | 1 | Inside | 58,000 | .0020375 | 106,000 | 18.00 | 44.58 | | |
| 8 | 15 | $A_3$ | | 2 | Middle | 54,000 | .0018625 | 104,000 | 18.25 | 43.25 | | |
| 8 | 15 | $A_3$ | | 3 | Outside | 57,000 | .0019125 | 104,400 | 17.625 | 41.91 | | |
| 8 | 18 | $A_3$ | | 1 | do | 64,000 | .0022125 | 106,800 | 15.50 | 40.55 | | |
| 8 | 18 | $A_3$ | | 2 | Middle | 52,000 | .0017625 | 98,400 | 19.25 | 45.11 | | |
| 8 | 18 | $A_3$ | | 3 | Inside | 60,000 | .0020625 | 109,600 | 15.75 | 39.45 | | |
| 8 | 19 | $A_3$ | | 1 | Outside | 62,000 | .0022250 | 109,600 | 13.625 | 37.79 | | |
| 8 | 19 | $A_3$ | | 2 | Inside | 61,000 | .0021500 | 108,400 | 14.005 | 44.05 | 7.8509 | 23.17 |
| 8 | 19 | $A_3$ | | 3 | Middle | 59,000 | .0020000 | 109,800 | 15.00 | 38.35 | | |
| 8 | 21 | $A_3$ | | 1 | Outside | 59,000 | .0020000 | 104,400 | 17.00 | 46.20 | | |
| 8 | 21 | $A_3$ | | 2 | Middle | 56,000 | .0019125 | 102,000 | 17.00 | 44.32 | | |
| 8 | 21 | $A_3$ | | 3 | Inside | 59,000 | .0020000 | 104,400 | 18.75 | 44.58 | | |
| 8 | 23 | $A_3$ | | 1 | Middle | 60,000 | .0020875 | 107,600 | 15.75 | 39.18 | 7.8521 | 22.39 |
| 8 | 24 | $A_3$ | | 1 | Outside | 63,000 | .0020750 | 108,800 | 16.875 | 44.05 | | |
| 8 | 24 | $A_3$ | | 2 | Middle | 59,000 | .0020375 | 109,600 | 17.125 | 41.91 | | |
| 8 | 24 | $A_3$ | | 3 | Inside | 62,000 | .0020500 | 110,000 | 16.25 | 41.10 | | |
| 10 | 2 | $A_3$ | Muzzle | 1 | Outside | 63,000 | .0021875 | 114,400 | 13.75 | 41.64 | | |
| 10 | 2 | $A_3$ | do | 2 | Inside | 60,000 | .0021875 | 112,800 | 15.375 | 40.83 | | |
| 10 | 2 | $A_3$ | do | 3 | Middle | 52,000 | .0018000 | 106,000 | 16.75 | 40.00 | | |
| 10 | 2 | $A_3$ | Breech | 1 | Outside | 57,000 | .0019750 | 107,200 | 18.25 | 43.52 | | |
| 10 | 2 | $A_3$ | do | 2 | Middle | 58,000 | .0020125 | 104,000 | 18.50 | 44.58 | | |
| 10 | 2 | $A_3$ | do | 3 | Inside | 60,000 | .0021250 | 108,000 | 16.75 | 47.45 | | |
| 10 | 4 | $A_3$ | Muzzle | 1 | Outside | 62,000 | .0022125 | 112,000 | 17.25 | 41.91 | | |
| 10 | 4 | $A_3$ | do | 2 | Inside | 64,000 | .0023125 | 114,800 | 14.75 | 34.39 | | |
| 10 | 4 | $A_3$ | do | 3 | Middle | 56,000 | .0019625 | 107,600 | 14.75 | 30.31 | | |
| 10 | 4 | $A_3$ | Breech | 1 | Outside | 63,000 | .0022250 | 114,000 | 12.50 | 28.52 | | |
| 10 | 4 | $A_3$ | do. | 2 | Middle | 60,000 | .0021625 | 112,800 | 12.75 | 38.07 | 7.8187 | 22.90 |
| 10 | 4 | $A_3$ | do | 3 | Inside | 66,000 | .0023250 | 115,200 | 13.25 | 38.07 | | |
| 12 | 2 | $A_3$ | Muzzle | 1 | Middle | 55,000 | .0019000 | 106,800 | 17.125 | 43.25 | | |
| 12 | 2 | $A_3$ | do | 2 | Outside | 61,000 | .0021500 | 108,400 | 17.25 | 45.11 | | |
| 12 | 2 | $A_3$ | do | 3 | Inside | 63,000 | .0022125 | 110,000 | 15.25 | 46.41 | | |
| 12 | 2 | $A_3$ | Breech | 1 | Outside | 59,000 | .0020375 | 104,000 | 17.00 | 49.99 | | |
| 12 | 2 | $A_3$ | do | 2 | Middle | 56,000 | .0020000 | 104,800 | 16.625 | 45.63 | 7.8534 | 23.84 |
| 12 | 2 | $A_3$ | do | 3 | Inside | 61,000 | .0021500 | 106,800 | 16.25 | 50.24 | | |
| 8 | 7 | $A_4$ | Muzzle | 1 | Outside | 58,000 | .0020125 | 108.000 | 17.25 | 44.32 | | |
| 8 | 7 | $A_4$ | do | 2 | Middle | 54,000 | .0018375 | 107,200 | 15.75 | 38.35 | | |
| 8 | 7 | $A_4$ | do | 3 | Inside | 61,000 | .0022250 | 109,200 | 13.25 | 42.18 | | |
| 8 | 7 | $A_4$ | Breech | 1 | Outside | 58,000 | .0019500 | 109,200 | 16.00 | 38.35 | | |
| 8 | 7 | $A_4$ | do | 2 | Inside | 62,000 | .0020875 | 114,000 | 13.875 | 35.82 | | |
| 8 | 7 | $A_4$ | do | 3 | Middle | 54,000 | .0018375 | 106,800 | 13.75 | 32.36 | | |
| 8 | 11 | $A_4$ | Muzzle | 1 | Outside | 55,000 | .0018875 | 94,400 | 21.25 | 48.47 | | |
| 8 | 11 | $A_4$ | do | 2 | Middle | 55,000 | .0018125 | 96,400 | 17.875 | 46.15 | | |
| 8 | 11 | $A_4$ | do | 3 | Inside | 58,000 | .0018625 | 99,200 | 17.875 | 46.41 | | |
| 8 | 11 | $A_4$ | Breech | 1 | Outside | 63,000 | .0021500 | 105,600 | 18.50 | 47.96 | | |
| 8 | 11 | $A_4$ | do | 2 | Inside | 54,000 | .0018250 | 96,400 | 19.75 | 48.47 | | |
| 8 | 11 | $A_4$ | do | 3 | Middle | 57,000 | .0019000 | 101,200 | 17.00 | 43.52 | | |
| 8 | *12 | $A_4$ | Muzzle | 1 | Outside | 56,000 | | 109,200 | 16.75 | 41.91 | | |
| 8 | *12 | $A_4$ | do | 2 | Inside | 54,000 | | 108,800 | 12.00 | 29.71 | | |
| 8 | *12 | $A_4$ | do | 3 | Middle | 50,000 | | 103,600 | 15.25 | 36.38 | | |
| 8 | *12 | $A_4$ | Breech | 1 | Outside | 59,000 | | 108,400 | 13.50 | 28.82 | | |
| 8 | *12 | $A_4$ | do | 2 | Middle | 56,000 | | 108,000 | 13.875 | 37.79 | | |
| 8 | *12 | $A_4$ | do | 3 | Inside | 59,000 | | 106,800 | 15.50 | 47.19 | | |
| 8 | 12 | $A_4$ | Muzzle | 4 | Middle | 57,000 | .0019875 | 109,200 | 17.75 | 37.79 | | |
| 8 | 12 | $A_4$ | do | 5 | Outside | 59,000 | .0020875 | 106,800 | 18.25 | 44.85 | | |
| 8 | 12 | $A_4$ | do | 6 | Inside | 63,000 | .0022250 | 113,600 | 14.625 | 40.83 | | |
| 8 | 12 | $A_4$ | Breech | 4 | do | 62,000 | .0021375 | 110,000 | 14.25 | 40.83 | | |
| 8 | 12 | $A_4$ | do | 5 | Outside | 61,000 | .0021250 | 108,400 | 16.125 | 45.89 | | |
| 8 | 12 | $A_4$ | do | 6 | Middle | 57,000 | .0019625 | 105,200 | 16.50 | 30.18 | | |
| 8 | *15 | $A_4$ | Muzzle | 1 | Outside | 55,000 | | 105,200 | 16.375 | 41.91 | | |
| 8 | *15 | $A_4$ | do | 2 | Middle | 52,000 | | 104,800 | 16.00 | 32.36 | | |
| 8 | *15 | $A_4$ | do | 3 | Inside | 59,000 | | 106,800 | 15.625 | 41.37 | | |
| 8 | *15 | $A_4$ | Breech | 1 | do | 56,000 | | 102,400 | 18.00 | 25.49 | | |
| 8 | *15 | $A_4$ | do | 2 | Middle | 50,000 | | 98,000 | 14.625 | 31.19 | | |
| 8 | *15 | $A_4$ | do | 3 | Outside | 56,000 | | 106,000 | 16.25 | 37.79 | | |
| 8 | 15 | $A_4$ | Muzzle | 4 | do | 54,000 | .0018875 | 100,000 | 17.25 | 52.95 | | |
| 8 | 15 | $A_4$ | do | 5 | Middle | 53,000 | .0018750 | 101,600 | 15.62 | 44.32 | | |
| 8 | 15 | $A_4$ | do | 6 | Inside | 58,000 | .0019875 | 105,200 | 15.00 | 48.47 | | |
| 8 | 15 | $A_4$ | Breech | 4 | Outside | 57,000 | .0020125 | 100,800 | 18.90 | 52.95 | | |

* Not accepted on these results; retempered and annealed.

*Results of tensile tests of tangential specimens from hoops for 8-inch, 10-inch, and 12-inch B. L. rifles*—Continued.

| Caliber. | Number of gun. | Mark of hoop. | Breech or muzzle. | Number of specimen. | Position of specimen. | Elastic limit per square inch of original section. | Elongation per inch under strain at elastic limit. | Tensile strength per square inch of original section. | Elongation after rupture. | Reduction of area after rupture. | Specific gravity. | Hardness. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Pounds.* | *Inch.* | *Pounds.* | *Per ct.* | *Per ct.* | | |
| 8 | 15 | $A_4$ | Breech.. | 5 | Middle.. | 53,000 | .0018250 | 104,000 | 14.75 | 44.58 | ........ | ....... |
| 8 | 15 | $A_4$ | ....do ... | 6 | Inside .. | 55,000 | .0018875 | 104,800 | 15.00 | 49.48 | ........ | ....... |
| 8 | 16 | $A_4$ | Muzzle . | 1 | Outside. | 61,000 | .0020750 | 112,000 | 15.50 | 34.96 | ........ | ....... |
| 8 | 16 | $A_4$ | ....do ... | 2 | Inside .. | 61,000 | .0020000 | 110,800 | 14.25 | 34.96 | ........ | ....... |
| 8 | 16 | $A_4$ | ....do ... | 3 | Middle.. | 57,000 | .0019375 | 108,800 | 14.00 | 35.82 | ........ | ....... |
| 8 | 16 | $A_4$ | Breech.. | 1 | Outside. | 63,000 | .0021375 | 110,000 | 16.75 | 45.37 | ........ | ....... |
| 8 | 16 | $A_4$ | ....do ... | 2 | Middle.. | 58,000 | .0019875 | 108,800 | 15.75 | 40.55 | 7.8548 | 23.17 |
| 8 | 16 | $A_4$ | ....do ... | 3 | Inside .. | 61,000 | .0020875 | 110,400 | 15.00 | 45.11 | ........ | ....... |
| 8 | 18 | $A_4$ | Muzzle . | 1 | Outside. | 63,000 | .0021250 | 109,600 | 15.875 | 47.45 | ........ | ....... |
| 8 | 18 | $A_4$ | ....do ... | 2 | Middle.. | 59,000 | .0020000 | 109,200 | 14.25 | 40.00 | ........ | ....... |
| 8 | 18 | $A_4$ | ....do ... | 3 | Inside .. | 63,000 | .0022000 | 112,000 | 15.25 | 44.05 | ........ | ....... |
| 8 | 18 | $A_4$ | Breech.. | 1 | Outside. | 62,000 | .0020750 | 112,000 | 13.375 | 15.68 | ........ | ....... |
| 8 | 18 | $A_4$ | ....do ... | 2 | Middle.. | 61,000 | .0021625 | 109,600 | 13.75 | 38.07 | ........ | ....... |
| 8 | 18 | $A_4$ | ....do ... | 3 | Inside .. | 62,000 | .0021500 | 110,000 | 16.00 | 44.31 | ........ | ....... |
| 8 | 20 | $A_4$ | Muzzle . | 1 | Outside. | 59,000 | .0020625 | 104,000 | 18.25 | 45.89 | ........ | ....... |
| 8 | 20 | $A_4$ | ....do ... | 2 | Inside .. | 60,000 | .0020125 | 108,000 | 16.125 | 46.67 | ........ | ....... |
| 8 | 20 | $A_4$ | ....do ... | 3 | Middle . | 58,000 | .0019750 | 103,600 | 17.25 | 44.58 | ........ | ....... |
| 8 | 20 | $A_4$ | Breech.. | 1 | Outside. | 57,000 | .0019250 | 106,800 | 16.00 | 39.45 | ........ | ....... |
| 8 | 20 | $A_4$ | ....do ... | 2 | Middle . | 55,000 | .0018875 | 102,000 | 16.75 | 33.52 | ........ | ....... |
| 8 | 20 | $A_4$ | ....do ... | 3 | Inside .. | 59,000 | .0019750 | 104,000 | 16.125 | 48.47 | ........ | ....... |
| 8 | 22 | $A_4$ | Muzzle . | 1 | Middle . | 61,000 | .0021625 | 106,000 | 11.375 | 16.92 | ........ | ....... |
| 8 | 22 | $A_4$ | ....do ... | 2 | Inside .. | 58,000 | .0019750 | 107,200 | 15.50 | 48.47 | ........ | ....... |
| 8 | 22 | $A_4$ | ....do ... | 3 | ....do ... | 63,000 | .0022250 | 108,000 | 15.00 | 49.23 | ........ | ....... |
| 8 | 22 | $A_4$ | ....do ... | 4 | Middle.. | 55,000 | .0018500 | 107,600 | 17.625 | 41.91 | ........ | ....... |
| 8 | 22 | $A_4$ | ....do ... | 5 | Inside .. | 64,000 | .0022625 | 110,000 | 15.25 | 48.72 | ........ | ....... |
| 8 | 22 | $A_4$ | ....do ... | 6 | Outside. | 56,000 | .0019125 | 100,000 | 11.50 | 39.45 | ........ | ....... |
| 8 | 22 | $A_4$ | Breech.. | 1 | ....do ... | 66,000 | .0021875 | 115,200 | 15.00 | 40.28 | ........ | ....... |
| 8 | 22 | $A_4$ | ....do ... | 2 | Middle.. | 61,000 | .0021125 | 112,000 | 13.75 | 42.18 | ........ | ....... |
| 8 | 22 | $A_4$ | ....do ... | 3 | Inside .. | 68,000 | .0022875 | 114,000 | 15.25 | 45.89 | ........ | ....... |
| 8 | 23 | $A_4$ | Muzzle . | 1 | Outside. | 61,000 | .0020750 | 106,400 | 18.25 | 45.37 | ........ | ....... |
| 8 | 23 | $A_4$ | ....do ... | 2 | Inside .. | 60,000 | .0020500 | 107,200 | 16.00 | 42.72 | ........ | ....... |
| 8 | 23 | $A_4$ | ....do ... | 3 | Middle.. | 59,000 | .0020750 | 107,200 | 15.00 | 40.28 | ........ | ....... |
| 8 | 23 | $A_4$ | Breech.. | 1 | Outside. | 60,000 | .0020375 | 108,000 | 14.875 | 39.73 | ........ | ....... |
| 8 | 23 | $A_4$ | ....do ... | 2 | Middle.. | 58,000 | .0020375 | 106,000 | 16.25 | 41.10 | ........ | ....... |
| 8 | 23 | $A_4$ | ....do ... | 3 | Inside .. | 64,000 | .0022125 | 110,000 | 17.00 | 45.89 | ........ | ....... |
| 10 | 2 | $A_4$ | .......... | 1 | Outside. | 57,000 | .0019125 | 102,400 | 16.625 | 46.15 | ........ | ....... |
| 10 | 2 | $A_4$ | .......... | 2 | Inside .. | 57,000 | .0019500 | 101,600 | 17.50 | 48.72 | ........ | ....... |
| 10 | 2 | $A_4$ | .......... | 3 | Middle.. | 55,000 | .0018750 | 100,000 | 14.50 | 35.82 | ........ | ....... |
| 10 | 4 | $A_4$ | .......... | 1 | Outside. | 64,000 | .0021125 | 109,600 | 15.125 | 45.63 | ........ | ....... |
| 10 | 4 | $A_4$ | .......... | 2 | Middle.. | 58,000 | .0019125 | 106,400 | 14.375 | 42.45 | ........ | ....... |
| 10 | 4 | $A_4$ | .......... | 3 | Inside .. | 65,000 | .0022500 | 113,600 | 14.50 | 44.32 | ........ | ....... |
| 8 | 6 | $A_5$ | .......... | 1 | Outside. | 59,000 | .0020500 | 116,000 | 18.00 | 43.52 | ........ | ....... |
| 8 | 6 | $A_5$ | .......... | 2 | Middle.. | 56,000 | .0019875 | 104,000 | 15.75 | 32.07 | 7.8522 | 21.64 |
| 8 | 6 | $A_5$ | .......... | 3 | Inside .. | 60,000 | .0020875 | 108,400 | 16.25 | 34.10 | ........ | ....... |
| 8 | 10 | $A_5$ | .......... | 1 | Outside. | 57,000 | .0019750 | 108,800 | 15.50 | 38.35 | ........ | ....... |
| 8 | 10 | $A_5$ | .......... | 2 | Middle.. | 53,000 | .0017750 | 103,200 | 17.875 | 36.38 | 7.8482 | 21.64 |
| 8 | 10 | $A_5$ | .......... | 3 | Inside .. | 57,000 | .0019750 | 106,000 | 14.50 | 40.00 | ........ | ....... |
| 8 | 14 | $A_5$ | .......... | 1 | Outside. | 59,000 | .0018750 | 105,600 | 15.25 | 31.78 | ........ | ....... |
| 8 | 14 | $A_5$ | .......... | 2 | Middle.. | 57,000 | .0019625 | 109,600 | 13.50 | 27.01 | 7.8520 | 20.93 |
| 8 | 14 | $A_5$ | .......... | 3 | Inside .. | 60,000 | .0019375 | 110,800 | 14.25 | 39.73 | ........ | ....... |
| 8 | 17 | $A_5$ | .......... | 1 | Outside. | 65,000 | .0021875 | 114,400 | 16.125 | 40.83 | ........ | ....... |
| 8 | 17 | $A_5$ | .......... | 2 | Middle.. | 54,000 | .0018750 | 108,400 | 12.375 | 40.00 | 7.8512 | 22.51 |
| 8 | 17 | $A_5$ | .......... | 3 | Inside .. | 62,000 | .0021750 | 114,000 | 17.50 | 40.28 | ........ | ....... |
| 8 | 19 | $A_5$ | .......... | 1 | Outside. | 60,000 | .0021125 | 108,400 | 17.50 | 39.18 | ........ | ....... |
| 8 | 19 | $A_5$ | .......... | 2 | Middle.. | 55,000 | .0019875 | 105,200 | 15.125 | 32.07 | 7.8504 | 22.14 |
| 8 | 19 | $A_5$ | .......... | 3 | Inside .. | 57,000 | .0020125 | 106,400 | 16.50 | 41.64 | ........ | ....... |
| 8 | *20 | $A_5$ | .......... | 1 | Outside. | 61,000 | .......... | 110,000 | 16.75 | 43.52 | ........ | ....... |
| 8 | *20 | $A_5$ | .......... | 2 | Middle.. | 50,000 | .......... | 99,200 | 16.75 | 42.45 | ........ | ....... |
| 8 | *20 | $A_5$ | .......... | 3 | Inside .. | 63,000 | .......... | 109,600 | 17.75 | 45.63 | ........ | ....... |
| 8 | 20 | $A_5$ | .......... | 4 | Outside. | 60,000 | .0020375 | 113,600 | 14.375 | 35.25 | ........ | ....... |
| 8 | 20 | $A_5$ | .......... | 5 | Middle.. | 62,000 | .0020625 | 113,600 | 14.25 | 35.82 | 7.8536 | 23.84 |
| 8 | 20 | $A_5$ | .......... | 6 | Inside .. | 67,000 | .0022375 | 115,200 | 15.25 | 39.73 | ........ | ....... |
| 8 | †22 | $A_5$ | .......... | 1 | Outside. | 59,000 | .......... | 113,600 | 15.00 | 38.62 | ........ | ....... |
| 8 | †22 | $A_5$ | .......... | 2 | Middle.. | 61,000 | .......... | 114,000 | 15.50 | 38.90 | ........ | ....... |
| 8 | †22 | $A_5$ | .......... | 3 | Inside .. | 62,000 | .......... | 110,800 | 7.00 | 8.64 | ........ | ....... |
| 8 | †22 | $A_5$ | .......... | 4 | ....do ... | 61,000 | .......... | 114,000 | 15.00 | 41.37 | ........ | ....... |
| 8 | †22 | $A_5$ | .......... | 5 | Outside. | 63,000 | .......... | 113,800 | 14.75 | 39.45 | ........ | ....... |
| 8 | †22 | $A_5$ | .......... | 6 | Middle.. | 58,000 | .......... | 111,600 | 16.75 | 38.90 | ........ | ....... |

* Not accepted on these results; retempered and annealed.
† Not accepted on these results; retested.

*Results of tensile tests of tangential specimens from hoops for 8-inch, 10-inch, and 12-inch B. L. rifles*—Continued.

| Caliber. | Number of gun. | Mark of hoop. | Breech or muzzle. | Number of specimen. | Position of specimen. | Elastic limit per square inch of original section. | Elongation per inch under strain at elastic limit. | Tensile strength per square inch of original section. | Elongation after rupture. | Reduction of area after rupture. | Specific gravity. | Hardness. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Pounds.* | *Inch.* | *Pounds.* | *Per ct.* | *Per ct.* | | |
| 8 | *22 | $A_5$ | .......... | 7 | Inside .. | 62,000 | .......... | 112,000 | 7.50 | 11.22 | .......... | .......... |
| 8 | *22 | $A_5$ | .......... | 8 | ....do ... | 63,000 | .......... | 114,400 | 9.50 | 12.82 | .......... | .......... |
| 8 | †22 | $A_5$ | .......... | 9 | Middle . | 61,000 | .......... | 108,800 | 16.25 | 43.79 | .......... | .......... |
| 8 | †22 | $A_5$ | .......... | 10 | Inside .. | 64,000 | .......... | 110,000 | 16.25 | 34.96 | .......... | .......... |
| 8 | †22 | $A_5$ | .......... | 11 | ....do ... | 64,000 | .......... | 109,200 | 8.00 | 9.32 | .......... | .......... |
| 8 | †22 | $A_5$ | .......... | 12 | Outside. | 66,000 | .......... | 110,400 | 15.625 | 43.79 | .......... | .......... |
| 8 | †22 | $A_5$ | .......... | 13 | Inside .. | 64,000 | .......... | 109,600 | 12.75 | 18.36 | .......... | .......... |
| 8 | †22 | $A_5$ | .......... | 14 | ....do ... | 63,000 | .......... | 109,600 | 15.50 | 46.41 | .......... | .......... |
| 8 | 22 | $A_5$ | .......... | 15 | Outside. | 62,000 | .0021625 | 105,600 | 17.75 | 46.67 | .......... | .......... |
| 8 | 22 | $A_5$ | .......... | 16 | Inside .. | 62,000 | .0021250 | 105,600 | 16.00 | 50.24 | .......... | .......... |
| 8 | 22 | $A_5$ | .......... | 17 | ....do ... | 61,000 | .0021000 | 106,000 | 15.75 | 50.73 | .......... | .......... |
| 8 | 22 | $A_5$ | .......... | 18 | ....do ... | 60,000 | .0020500 | 104,400 | 17.75 | 50.98 | .......... | .......... |
| 8 | 22 | $A_5$ | .......... | 19 | Middle . | 52,000 | .0017625 | 101,600 | 18.50 | 42.99 | .......... | .......... |
| 8 | 22 | $A_5$ | .......... | 20 | Inside .. | 63,000 | .0020625 | 106,400 | 17.75 | 50.24 | .......... | .......... |
| 8 | 23 | $A_5$ | .......... | 1 | Outside. | 60,000 | .0020500 | 108,000 | 16.875 | 38.90 | .......... | .......... |
| 8 | 23 | $A_5$ | .......... | 2 | Middle . | 58,000 | .0019750 | 110,000 | 14.375 | 35.25 | .......... | .......... |
| 8 | 23 | $A_5$ | .......... | 3 | Inside .. | 62,000 | .0021750 | 108,800 | 16.25 | 40.28 | .......... | .......... |
| 10 | *2 | $A_5$ | .......... | 1 | Outside. | 50,000 | .......... | 88,000 | 19.125 | 50.98 | .......... | .......... |
| 10 | *2 | $A_5$ | .......... | 2 | Inside .. | 54,000 | .......... | 91,600 | 21.00 | 51.23 | .......... | .......... |
| 10 | *2 | $A_5$ | .......... | 3 | Middle . | 55,000 | .......... | 94,000 | 21.25 | 48.22 | .......... | .......... |
| 10 | 2 | $A_5$ | .......... | 4 | Outside. | 59,000 | .0020625 | 104,400 | 18.25 | 48.22 | .......... | .......... |
| 10 | 2 | $A_5$ | .......... | 5 | Inside .. | 55,000 | .0019375 | 95,200 | 18.00 | 49.48 | .......... | .......... |
| 10 | 2 | $A_5$ | .......... | 6 | Middle . | 57,000 | .0019375 | 97,200 | 17.375 | 47.70 | .......... | .......... |
| 12 | 2 | $A_5$ | Muzzle . | 1 | Outside. | 64,000 | .0022250 | 111,600 | 16.00 | 46.15 | .......... | .......... |
| 12 | 2 | $A_5$ | ....do ... | 2 | Inside .. | 65,000 | .0020125 | 112,800 | 14.75 | 45.63 | .......... | .......... |
| 12 | 2 | $A_5$ | ....do ... | 3 | Middle.. | 62,000 | .0021500 | 111,200 | 16.75 | 45.37 | .......... | .......... |
| 12 | 2 | $A_5$ | Breech.. | 1 | Outside. | 62,000 | .0021125 | 112,800 | 16.75 | 43.25 | .......... | .......... |
| 12 | 2 | $A_5$ | ....do ... | 2 | Middle.. | 58,000 | .0020125 | 110,000 | 16.00 | 42.18 | .......... | .......... |
| 12 | 2 | $A_5$ | ....do ... | 3 | Inside .. | 66,000 | .0022500 | 112,800 | 13.75 | 46.15 | .......... | .......... |
| 10 | 2 | $B_2$ | Muzzle . | 1 | Outside. | 55,000 | .0020375 | 102,000 | 18.00 | 46.67 | .......... | .......... |
| 10 | 2 | $B_2$ | ....do ... | 2 | Middle.. | 53,000 | .0018250 | 97,600 | 18.625 | 42.99 | .......... | .......... |
| 10 | 2 | $B_2$ | ....do ... | 3 | Inside .. | 56,000 | .0018875 | 102,400 | 18.00 | 47.96 | .......... | .......... |
| 10 | 2 | $B_2$ | Breech.. | 1 | Outside. | 55,000 | .0018625 | 104,000 | 17.125 | 45.63 | .......... | .......... |
| 10 | 2 | $B_2$ | ....do ... | 2 | Middle.. | 53,000 | .0018625 | 100,800 | 16.50 | 40.28 | .......... | .......... |
| 10 | 2 | $B_2$ | ....do ... | 3 | Inside .. | 57,000 | .0019000 | 104,400 | 17.50 | 45.11 | .......... | .......... |
| 10 | 3 | $B_2$ | Muzzle . | 1 | Outside. | 59,000 | .0021625 | 106,000 | 19.50 | 46.15 | .......... | .......... |
| 10 | 3 | $B_2$ | ....do ... | 2 | Middle.. | 58,000 | .0021250 | 107,200 | 16.75 | 40.83 | .......... | .......... |
| 10 | 3 | $B_2$ | ....do ... | 3 | Inside .. | 60,000 | .0022125 | 106,800 | 16.00 | 44.05 | .......... | .......... |
| 10 | 3 | $B_2$ | Breech.. | 1 | Outside. | 58,000 | .0020125 | 108,400 | 15.50 | 40.28 | .......... | .......... |
| 10 | 3 | $B_2$ | ....do ... | 2 | Middle.. | 52,000 | .0018500 | 106,400 | 16.25 | 38.07 | .......... | .......... |
| 10 | 3 | $B_2$ | ....do ... | 3 | Inside .. | 58,000 | .0020875 | 107,200 | 17.50 | 41.91 | .......... | .......... |
| 10 | 4 | $B_2$ | Muzzle.. | 1 | Outside. | 60,000 | .0020375 | 110,400 | 14.00 | 35.53 | .......... | .......... |
| 10 | 4 | $B_2$ | ....do ... | 2 | Middle.. | 56,000 | .0018750 | 107,200 | 14.00 | 30.60 | .......... | .......... |
| 10 | 4 | $B_2$ | ....do ... | 3 | Inside .. | 57,000 | .0019375 | 110,000 | 14.75 | 30.31 | .......... | .......... |
| 10 | 4 | $B_2$ | Breech.. | 1 | Outside. | 59,000 | .0020125 | 111,200 | 14.50 | 33.81 | .......... | .......... |
| 10 | 4 | $B_2$ | ....do ... | 2 | Middle.. | 58,000 | .0019875 | 109,600 | 13.25 | 32.07 | .......... | .......... |
| 10 | 4 | $B_2$ | ....do ... | 3 | Inside .. | 61,000 | .0020750 | 109,600 | 13.00 | 36.67 | .......... | .......... |
| 12 | 2 | $B_2$ | Muzzle . | 1 | Outside. | 61,000 | .0020625 | 107,200 | 14.75 | 45.89 | .......... | .......... |
| 12 | 2 | $B_2$ | ....do ... | 2 | Middle.. | 58,000 | .0019875 | 107,200 | 15.625 | 41.64 | .......... | .......... |
| 12 | 2 | $B_2$ | ....do ... | 3 | Inside .. | 64,000 | .0022500 | 110,800 | 15.25 | 45.89 | .......... | .......... |
| 12 | 2 | $B_2$ | ....do ... | 4 | Middle.. | 59,000 | .00203750 | 108,000 | 15.125 | 42.99 | .......... | .......... |
| 12 | 2 | $B_2$ | Breech.. | 1 | Outside. | 58,000 | .0019625 | 108,800 | 14.625 | 37.79 | .......... | .......... |
| 12 | 2 | $B_2$ | ....do ... | 2 | Middle.. | 57,000 | .0020000 | 107,600 | 14.25 | 36.67 | .......... | .......... |
| 12 | 2 | $B_2$ | ....do ... | 3 | Inside .. | 66,000 | .0023625 | 108,800 | 13.00 | 40.83 | .......... | .......... |
| 12 | 2 | $B_2$ | ....do ... | 4 | Middle.. | 55,000 | .0019750 | 106,400 | 13.50 | 32.94 | .......... | .......... |
| 12 | 3 | $B_2$ . | Muzzle . | 1 | Outside. | 61,000 | .0020250 | 104,400 | 17.625 | 49.73 | .......... | .......... |
| 12 | 3 | $B_2$ . | ....do ... | 2 | Inside .. | 63,000 | .0021500 | 107,600 | 16.00 | 51.48 | .......... | .......... |
| 12 | 3 | $B_2$ . | ....do ... | 3 | Middle . | 59,000 | .0020000 | 107,200 | 15.00 | 40.55 | .......... | .......... |
| 12 | 3 | $B_2$ . | ....do ... | 4 | ....do ... | 60,000 | .0020500 | 108,000 | 17.75 | 41.37 | .......... | .......... |
| 12 | 3 | $B_2$ . | Breech.. | 1 | Outside. | 61,000 | .0020875 | 110,400 | 17.50 | 35.53 | .......... | .......... |
| 12 | 3 | $B_2$ . | ....do ... | 2 | Middle . | 59,000 | .0020125 | 109,200 | 17.875 | 44.58 | .......... | .......... |
| 12 | 3 | $B_2$ . | ....do ... | 3 | Inside .. | 62,000 | .0021125 | 106,800 | 14.50 | 47.96 | .......... | .......... |
| 12 | 3 | $B_2$ . | ....do ... | 4 | Middle . | 57,000 | .0019375 | 108,800 | 17.125 | 43.25 | .......... | .......... |
| 10 | 2 | $B_3$ . | Muzzle . | 1 | Outside. | 55,000 | .0019625 | 102,000 | 20.50 | 44.58 | .......... | .......... |
| 10 | 2 | $B_3$ . | ....do ... | 2 | Inside .. | 55,000 | .0019125 | 95,200 | 20.625 | 48.98 | .......... | .......... |
| 10 | 2 | $B_3$ . | ....do ... | 3 | Middle . | 54,000 | .0019125 | 96,000 | 18.00 | 42.18 | .......... | .......... |
| 10 | 2 | $B_3$ . | Breech.. | 1 | Outside. | 55,000 | .0020000 | 97,600 | 20.25 | 47.19 | .......... | .......... |

* Not accepted on these results; retempered and annealed.
† Not accepted on these results; reannealed.

*Results of tensile tests of tangential specimens from hoops for 8-inch, 10-inch, and 12-inch B. L. rifles*—Continued.

| Caliber. | Number of gun. | Mark of hoop. | Breech or muzzle. | Number of specimen. | Position of specimen. | Elastic limit per square inch of original section. | Elongation per inch under strain at elastic limit. | Tensile strength per square inch of original section. | Elongation after rupture. | Reduction of area after rupture. | Specific gravity. | Hardness. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Pounds.* | *Inch.* | *Pounds.* | *Per ct.* | *Per ct.* | | |
| 10 | 2 | $B_3$ | Breech | 2 | Middle | 53,000 | .0018375 | 96,000 | 20.875 | 47.19 | ........ | ........ |
| 10 | 2 | $B_3$ | ....do... | 3 | Inside | 57,000 | .0019250 | 99,600 | 19.375 | 43.79 | ........ | ........ |
| 12 | 2 | $B_3$ | Muzzle | 1 | Outside | 65,000 | .0022375 | 111,600 | 17.25 | 46.93 | ........ | ........ |
| 12 | 2 | $B_3$ | ....do... | 2 | Middle | 60,000 | .0020750 | 109,600 | 16.875 | 45.37 | ........ | ........ |
| 12 | 2 | $B_3$ | ....do... | 3 | Inside | 66,000 | .0023375 | 113,200 | 16.00 | 44.32 | ........ | ........ |
| 12 | 2 | $B_3$ | ....do... | 4 | Middle | 62,000 | .0021375 | 110,000 | 17.875 | 47.96 | ........ | ........ |
| 12 | 2 | $B_3$ | Breech | 1 | ....do... | 59,000 | .0020375 | 112,000 | 13.375 | 32.94 | ........ | ........ |
| 12 | 2 | $B_3$ | ....do... | 2 | Outside | 67,000 | ,0022750 | 115,200 | 15,875 | 44.05 | ........ | ........ |
| 12 | 2 | $B_3$ | ....do... | 3 | Middle | 60,000 | .0020750 | 114,400 | 14.50 | 36.38 | ........ | ........ |
| 12 | 2 | $B_3$ | ....do... | 4 | Inside | 66,000 | .0022375 | 114,000 | 15.50 | 44.58 | ........ | ........ |
| 10 | *2 | $B_4$ | Muzzle | 1 | Outside | 57,000 | .......... | 98,800 | 20.50 | 47.70 | ........ | ........ |
| 10 | *2 | $B_4$ | ....do... | 2 | Inside | 54,000 | .......... | 99,200 | 17.50 | 47.96 | ........ | ........ |
| 10 | *2 | $B_4$ | ....do... | 3 | Middle | 54,000 | .......... | 95,600 | 21.75 | 47.45 | ........ | ........ |
| 10 | *2 | $B_4$ | Breech | 1 | Outside | 55,000 | .......... | 97,600 | 18.75 | 45.89 | ........ | ........ |
| 10 | *2 | $B_4$ | ....do... | 2 | Inside | 50,000 | .......... | 93,600 | 20.00 | 49.48 | ........ | ........ |
| 10 | *2 | $B_4$ | ....do... | 3 | Middle | 50,000 | .......... | 99,200 | 18.75 | 46.67 | ........ | ........ |
| 10 | 2 | $B_4$ | Muzzle | 4 | Inside | 60,000 | .0020375 | 109,200 | 16.00 | 45.63 | ........ | ........ |
| 10 | 2 | $B_4$ | ....do... | 5 | Middle | 54,000 | .0018250 | 105,200 | 16.00 | 42.45 | ........ | ........ |
| 10 | 2 | $B_4$ | ....do... | 6 | Outside | 57,000 | .0019000 | 106,000 | 16.75 | 46.15 | ........ | ........ |
| 10 | 2 | $B_4$ | ....do... | 7 | ....do... | 58,000 | .0020000 | 108,000 | 15.75 | 42.72 | ........ | ........ |
| 10 | 2 | $B_4$ | ....do... | 8 | Middle | 53,000 | .0018250 | 106,800 | 16.25 | 41.91 | ........ | ........ |
| 10 | 2 | $B_4$ | ....do... | 9 | Inside | 52,000 | .0018000 | 103,200 | 15.00 | 41.37 | ........ | ........ |
| 10 | 2 | $B_4$ | Breech | 4 | Outside | 59,000 | ,0019625 | 104,400 | 18.25 | 47.19 | ........ | ........ |
| 10 | 2 | $B_4$ | ....do... | 5 | Middle | 54,000 | .0019750 | 101,200 | 18.25 | 44.32 | ........ | ........ |
| 10 | 2 | $B_4$ | ....do... | 6 | Inside | 55,000 | .0018875 | 105,000 | 16.25 | 47.19 | ........ | ........ |
| 10 | 3 | $B_4$ | Muzzle | 1 | Middle | 58,000 | .0019375 | 110,000 | 13.75 | 37.51 | ........ | ........ |
| 10 | 3 | $B_4$ | ....do... | 2 | Outside | 58,000 | .0020125 | 110,800 | 15.50 | 37.51 | ........ | ........ |
| 10 | 3 | $B_4$ | ....do... | 3 | Inside | 60,000 | .0020250 | 111,600 | 14.75 | 38.90 | ........ | ........ |
| 10 | 3 | $B_4$ | Breech | 1 | Outside | 61,000 | .0020875 | 111,200 | 15.50 | 40.28 | ........ | ........ |
| 10 | 3 | $B_4$ | ....do... | 2 | Inside | 60,000 | .0019750 | 113,600 | 12.75 | 36.19 | ........ | ........ |
| 10 | 3 | $B_4$ | ....do... | 3 | Middle | 57,000 | .0019125 | 110,000 | 16.50 | 35.25 | 7.851 | 22.77 |
| 10 | 4 | $B_4$ | Muzzle | 1 | Outside | 59,000 | .0020750 | 104,800 | 15.875 | 43.52 | ........ | ........ |
| 10 | 4 | $B_4$ | ....do... | 2 | Middle | 56,000 | .0020375 | 104,000 | 16.50 | 41.10 | ........ | ........ |
| 10 | 4 | $B_4$ | ....do... | 3 | Inside | 60,000 | .0020875 | 106,000 | 16.875 | 40.28 | ........ | ........ |
| 10 | 4 | $B_4$ | Breech | 1 | Outside | 56,000 | .0019625 | 104,000 | 17.25 | 46.93 | ........ | ........ |
| 10 | 4 | $B_4$ | ....do... | 2 | Inside | 59,000 | .0021000 | 104,800 | 17.50 | 47.96 | ........ | ........ |
| 10 | 4 | $B_4$ | ....do... | 3 | Middle | 55,000 | .0018875 | 103,600 | 15.00 | 35.25 | ........ | ........ |
| 10 | 5 | $B_4$ | Muzzle | 1 | Inside | 61,000 | .0022250 | 108,800 | 15.25 | 44.85 | ........ | ........ |
| 10 | 5 | $B_4$ | ....do... | 2 | Middle | 57,000 | .0019625 | 107,200 | 13.875 | 39.18 | ........ | ........ |
| 10 | 5 | $B_4$ | ....do... | 3 | Outside | 58,000 | .0019625 | 108,400 | 14.75 | 38.35 | ........ | ........ |
| 10 | 5 | $B_4$ | Breech | 1 | ....do... | 54,000 | .0018625 | 106,000 | 16.00 | 41.91 | ........ | ........ |
| 10 | 5 | $B_4$ | ....do... | 2 | Middle | 55,000 | .0018875 | 104,000 | 16.125 | 43.52 | ........ | ........ |
| 10 | 5 | $B_4$ | ....do... | 3 | Inside | 57,000 | .0019500 | 106,800 | 15.00 | 46.15 | ........ | ........ |
| 12 | 2 | $B_4$ | Muzzle | 1 | Outside | 60,000 | .0020250 | 104,800 | 18.50 | 40.55 | ........ | ........ |
| 12 | 3 | $B_4$ | ....do... | 2 | Middle | 55,000 | .0019500 | 105,200 | 13.75 | 34.39 | ........ | ........ |
| 12 | 2 | $B_4$ | ....do... | 3 | ....do... | 51,000 | .0017500 | 103,600 | 14.25 | 21.46 | ........ | ........ |
| 12 | 2 | $B_4$ | ....do... | 4 | Inside | 58,000 | .0018750 | 106,000 | 15.75 | 37.79 | ........ | ........ |
| 12 | 2 | $B_4$ | Breech | 1 | Outside | 57,000 | .0019500 | 104,800 | 17.50 | 37.79 | ........ | ........ |
| 12 | 2 | $B_4$ | ....do... | 2 | Inside | 58,000 | .0019875 | 106,800 | 14.375 | 33.52 | ........ | ........ |
| 12 | 2 | $B_4$ | ....do... | 3 | Middle | 56,000 | .0020375 | 104,400 | 13.75 | 34.96 | ........ | ........ |
| 12 | 2 | $B_4$ | ....do... | 4 | ....do... | 54,000 | .0018500 | 104,800 | 14.50 | 33.23 | ........ | ........ |
| 8 | 7 | $D_1$ | .......... | 1 | ....do... | 57,000 | .0020250 | 106,400 | 16.625 | 33.81 | ........ | ........ |
| 8 | 7 | $D_1$ | .......... | 2 | Outside | 56,000 | .0019250 | 106,000 | 13.50 | 22.40 | ........ | ........ |
| 8 | 7 | $D_1$ | .......... | 3 | Inside | 60,000 | .0022000 | 107,600 | 14.50 | 43.52 | ........ | ........ |
| 8 | 11 | $D_1$ | .......... | 1 | Outside | 56,000 | .0019375 | 104,000 | 15.25 | 38.35 | ........ | ........ |
| 8 | 11 | $D_1$ | .......... | 2 | Middle | 58,000 | .0019500 | 104.000 | 14.50 | 38.62 | ........ | ........ |
| 8 | 11 | $D_1$ | .......... | 3 | Inside | 62,000 | .0021750 | 108,000 | 11.625 | 26.10 | ........ | ........ |
| 8 | †14 | $D_1$ | .......... | 1 | Outside | 63,000 | .......... | 114,000 | 16.00 | 42.99 | ........ | ........ |
| 8 | †14 | $D_1$ | .......... | 2 | Middle | 62,000 | .......... | 114,800 | 9.875 | 9.64 | ........ | ........ |
| 8 | †14 | $D_1$ | .......... | 3 | Inside | 66,000 | .......... | 117,200 | 13.25 | 36.67 | ........ | ........ |
| 8 | 14 | $D_1$ | .......... | 4 | Outside | 60,000 | .0021500 | 106,800 | 16.75 | 57.22 | ........ | ........ |
| 8 | 14 | $D_1$ | .......... | 5 | Inside | 61,000 | .0020375 | 106,400 | 16.25 | 49.48 | ........ | ........ |
| 8 | 14 | $D_1$ | .......... | 6 | Middle | 52,000 | .0018125 | 104,000 | 16.50 | 47.70 | ........ | ........ |
| 8 | 15 | $D_1$ | .......... | 1 | Outside | 59,000 | .0017375 | 106,800 | 17.25 | 43.52 | ........ | ........ |
| 8 | 15 | $D_1$ | .......... | 2 | Middle | 56,000 | .0019125 | 105,200 | 14.50 | 40.28 | ........ | ........ |
| 8 | 15 | $D_1$ | .......... | 3 | Inside | 53,000 | .0016500 | 108,000 | 16.00 | 43.25 | ........ | ........ |
| 8 | 18 | $D_1$ | .......... | 1 | Outside | 64,000 | .0021500 | 105,200 | 18.50 | 47.96 | ........ | ........ |

* Not accepted on these results; retempered and annealed.

† Not accepted on these results; reannealed.

***Results of tensile tests of tangential specimens from hoops for 8-inch, 10-inch, and 12-inch B. L. rifles*—Continued.**

| Caliber. | Number of gun. | Mark of hoop. | Breech or muzzle | Number of specimen. | Position of specimen. | Elastic limit per square inch of original section. | Elongation per inch under strain at elastic limit. | Tensile strength per square inch of original section. | Elongation after rupture. | Reduction of area after rupture. | Specific gravity. | Hardness. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Pounds.* | *Inch.* | *Pounds.* | *Per ct.* | *Per ct.* | | |
| 8 | 18 | $D_1$ | .......... | 2 | Middle.. | 59,000 | .0020875 | 104,800 | 17.50 | 43.25 | ....... | ....... |
| 8 | 18 | $D_1$ | .......... | 3 | Inside .. | 63,000 | .0020125 | 105,600 | 17.50 | 49.73 | ....... | ....... |
| 8 | 20 | $D_1$ | .......... | 1 | Outside . | 62,000 | .0020750 | 112,400 | 14.75 | 37.79 | ....... | ....... |
| 8 | 20 | $D_1$ | .......... | 2 | Inside .. | 62,000 | .0021000 | 111,600 | 15.00 | 39.73 | ....... | ....... |
| 8 | 20 | $D_1$ | .......... | 3 | Middle.. | 59,000 | .0020625 | 112,000 | 15.25 | 36.38 | ....... | ....... |
| 8 | 21 | $D_1$ | .......... | 1 | Outside . | 59,000 | .0020625 | 104,800 | 14.25 | 24.88 | ....... | ....... |
| 8 | 21 | $D_1$ | .......... | 2 | Middle.. | 55,000 | .0018500 | 101,600 | 17.25 | 42.18 | ....... | ....... |
| 8 | 21 | $D_1$ | .......... | 3 | Inside .. | 59,000 | .0020125 | 106,000 | 16.00 | 45.37 | ....... | ....... |
| 10 | 2 | $D_1$ | Muzzle . | 1 | ....do ... | 59,000 | .0019000 | 104,000 | 15.25 | 43.25 | ....... | ....... |
| 10 | 2 | $D_1$ | ....do ... | 2 | Middle.. | 54,000 | .0018625 | 102,400 | 18.25 | 39.73 | ....... | ....... |
| 10 | 2 | $D_1$ | ....do ... | 3 | Outside . | 58,000 | .0019625 | 106,800 | 14.00 | 40.28 | ....... | ....... |
| 10 | 2 | $D_1$ | Breech .. | 1 | ....do ... | 60,000 | .0020625 | 106,400 | 16.50 | 42.45 | ....... | ....... |
| 10 | 2 | $D_1$ | ....do ... | 2 | Middle.. | 55,000 | .0018750 | 102,000 | 18.00 | 35.82 | ....... | ....... |
| 10 | 2 | $D_1$ | ....do ... | 3 | Inside .. | 61,000 | .0020125 | 106,400 | 15.00 | 45.89 | ....... | ....... |
| 10 | *3 | $D_1$ | Muzzle . | 1 | Outside . | 61,000 | .......... | 111,200 | 13.75 | 35.82 | ....... | ....... |
| 10 | *3 | $D_1$ | ....do ... | 2 | Middle.. | 58,000 | .......... | 110,400 | 13.25 | 33.23 | ....... | ....... |
| 10 | *3 | $D_1$ | ....do ... | 3 | Inside .. | 63,000 | .......... | 112,000 | 10.00 | 18.05 | ....... | ....... |
| 10 | *3 | $D_1$ | Breech . | 1 | Outside . | 61,000 | .......... | 112,800 | 13.00 | 38.90 | ....... | ....... |
| 10 | *3 | $D_1$ | ....do ... | 2 | Middle.. | 61,000 | .......... | 113,200 | 12.00 | 24.57 | ....... | ....... |
| 10 | *3 | $D_1$ | ....do ... | 3 | Inside .. | 63,000 | .......... | 113,600 | 14.50 | 37.79 | ....... | ....... |
| 10 | 3 | $D_1$ | Muzzle . | 4 | Outside . | 62,000 | .0021500 | 108,400 | 16.625 | 43.79 | ....... | ....... |
| 10 | 3 | $D_1$ | ....do ... | 5 | Inside .. | 62,000 | .0021000 | 108,000 | 16.00 | 39.45 | ....... | ....... |
| 10 | 3 | $D_1$ | ....do ... | 6 | Middle.. | 53,000 | .0018875 | 104,800 | 15.25 | 44.85 | ....... | ....... |
| 10 | 3 | $D_1$ | Breech .. | 4 | Outside . | 62,000 | .0021000 | 108,400 | 17.50 | 43.79 | ....... | ....... |
| 10 | 3 | $D_1$ | ....do ... | 5 | Inside .. | 63,000 | .0021375 | 108,800 | 13.50 | 44.32 | ....... | ....... |
| 10 | 3 | $D_1$ | ....do ... | 6 | Middle.. | 57,000 | .0019250 | 106,400 | 16.50 | 42.18 | ....... | ....... |
| 12 | 2 | $D_1$ | Muzzle . | 1 | Outside. | 61,000 | .0020750 | 106,800 | 14.875 | 41.37 | ....... | ....... |
| 12 | 2 | $D_1$ | ....do ... | 2 | Middle . | 59,000 | .0020000 | 106,400 | 14.25 | 39.18 | ....... | ....... |
| 12 | 2 | $D_1$ | ....do ... | 3 | Inside .. | 61,000 | .0022500 | 106,000 | 14.75 | 42.72 | ....... | ....... |
| 12 | 2 | $D_1$ | Breech .. | 1 | Outside. | 61,000 | .0020000 | 106,400 | 15.75 | 45.89 | ....... | ....... |
| 12 | 2 | $D_1$ | ....do ... | 2 | Middle . | 54,000 | .0018250 | 106,000 | 16.25 | 39.18 | ....... | ....... |
| 12 | 2 | $D_1$ | ....do ... | 3 | Inside .. | 60,000 | .0020000 | 106,400 | 17.50 | 40.28 | ....... | ....... |
| 8 | 2 | $D_2$ | .......... | 1 | ....do ... | 63,000 | .0023125 | 109,200 | 15.50 | 40.83 | ....... | ....... |
| 8 | 2 | $D_2$ | .......... | 2 | Outside. | 61,000 | .0021875 | 105,600 | 18.00 | 47.19 | ....... | ....... |
| 8 | 2 | $D_2$ | .......... | 3 | Middle . | 59,000 | .0021000 | 106,000 | 16.75 | 45.11 | ....... | ....... |
| 8 | 4 | $D_2$ | .......... | 1 | Inside .. | 58,000 | .0020250 | 104,800 | 17.00 | 48.47 | ....... | ....... |
| 8 | 4 | $D_2$ | .......... | 2 | Outside. | 60,000 | .0020750 | 103,600 | 17.50 | 47.19 | ....... | ....... |
| 8 | 4 | $D_2$ | .......... | 3 | Middle . | 56,000 | .0019625 | 106,400 | 16.125 | 30.60 | ....... | ....... |
| 8 | 5 | $D_2$ | .......... | 4 | Inside .. | 57,000 | .0019750 | 102,000 | 13.25 | 30.31 | ....... | ....... |
| 8 | 5 | $D_2$ | .......... | 5 | Middle . | 54,000 | .0018625 | 99,600 | 20.50 | 44.85 | ....... | ....... |
| 8 | 5 | $D_2$ | .......... | 6 | Outside. | 57,000 | .0026125 | 100,400 | 15.50 | 44.32 | ....... | ....... |
| 8 | 7 | $D_2$ | .......... | 1 | Inside .. | 58,000 | .0020000 | 108,800 | 13.90 | 33.81 | ....... | ....... |
| 8 | 7 | $D_2$ | .......... | 2 | Outside. | 61,000 | .0021125 | 110,000 | 15.475 | 39.45 | ....... | ....... |
| 8 | 7 | $D_2$ | .......... | 3 | Middle . | 57,000 | .0020375 | 106,400 | 15.00 | 31.78 | ....... | ....... |
| 8 | 9 | $D_2$ | .......... | 4 | Outside. | 56,000 | .0019625 | 99,600 | 17.25 | 38.07 | ....... | ....... |
| 8 | 9 | $D_2$ | .......... | 5 | Inside .. | 57,000 | .0019375 | 100,000 | 18.375 | 41.64 | ....... | ....... |
| 8 | 9 | $D_2$ | .......... | 6 | Middle . | 56,000 | .0018875 | 97,200 | 19.50 | 41.37 | ....... | ....... |
| 8 | †10 | $D_2$ | .......... | 1 | Outside. | 59,000 | .......... | 105,600 | 16.125 | 40.55 | ....... | ....... |
| 8 | †10 | $D_2$ | .......... | 2 | Middle . | 62,000 | .......... | 105,600 | 15.25 | 38.62 | ....... | ....... |
| 8 | †10 | $D_2$ | .......... | 3 | Inside .. | 50,000 | .......... | 96,400 | 20.25 | 39.18 | ....... | ....... |
| 8 | 10 | $D_2$ | .......... | 4 | Outside. | 65,000 | .0021875 | 113,200 | 14.125 | 42.45 | ....... | ....... |
| 8 | 10 | $D_2$ | .......... | 5 | Inside .. | 64,000 | .0022625 | 115,200 | 13.00 | 26.71 | ....... | ....... |
| 8 | 10 | $D_2$ | .......... | 6 | Middle . | 61,000 | .0021125 | 111,600 | 14.00 | 38.62 | ....... | ....... |
| 8 | 12 | $D_2$ | .......... | 1 | Outside. | 63,000 | .0021750 | 109,600 | 15.75 | 43.79 | ....... | ....... |
| 8 | 12 | $D_2$ | .......... | 2 | Inside .. | 64,000 | .0021250 | 110,800 | 11.625 | 25.80 | ....... | ....... |
| 8 | 12 | $D_2$ | .......... | 3 | Middle . | 61,000 | .0021000 | 106,800 | 16.25 | 41.37 | ....... | ....... |
| 8 | †14 | $D_2$ | .......... | 1 | Outside. | 57,000 | .......... | 100,400 | 19.00 | 50.73 | ....... | ....... |
| 8 | †14 | $D_2$ | .......... | 2 | Middle . | 55,000 | .......... | 103,200 | 17.00 | 43.52 | ....... | ....... |
| 8 | †14 | $D_2$ | .......... | 3 | Inside .. | 58,000 | .......... | 103,200 | 10.50 | 13.32 | ....... | ....... |
| 8 | 14 | $D_2$ | .......... | 4 | Outside. | 53,000 | .0018000 | 99,600 | 18.75 | 47.45 | ....... | ....... |
| 8 | 14 | $D_2$ | .......... | 5 | Middle . | 54,000 | .0018000 | 99,600 | 17.25 | 44.32 | ....... | ....... |
| 8 | 14 | $D_2$ | .......... | 6 | Inside .. | 55,000 | .0018250 | 102,800 | 19.75 | 48.47 | ....... | ....... |
| 8 | 16 | $D_2$ | .......... | 1 | Outside. | 60,000 | .0021125 | 107,200 | 17.00 | 44.58 | ....... | ....... |
| 8 | 16 | $D_2$ | .......... | 2 | Middle . | 57,000 | .0020750 | 105,200 | 15.25 | 40.83 | ....... | ....... |
| 8 | 16 | $D_2$ | .......... | 3 | Inside .. | 58,000 | .0018750 | 106,400 | 17.75 | 40.83 | ....... | ....... |
| 8 | 17 | $D_2$ | .......... | 1 | Outside. | 59,000 | .0020875 | 106,400 | 17.25 | 40.83 | ....... | ....... |
| 8 | 17 | $D_2$ | .......... | 2 | Middle . | 56,000 | .0019125 | 104,800 | 14.00 | 30.31 | ....... | ....... |

* Not accepted on these results; reannealed.

† Not accepted on these results; retempered and annealed.

*Results of tensile tests of tangential specimens from hoops for 8-inch, 10-inch, and 12-inch B. L. rifles*—Continued.

| Caliber. | Number of gun. | Mark of hoop. | Breech or muzzle. | Number of specimen. | Position of specimen. | Elastic limit per square inch of original section. | Elongation per inch under strain at elastic limit. | Tensile strength per square inch of original section. | Elongation after rupture. | Reduction of area after rupture. | Specific gravity | Hardness. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Pounds.* | *Inch.* | *Pounds.* | *Per ct.* | *Per ct.* | | |
| 8 | 17 | $D_2$ | .......... | 3 | Inside .. | 61,000 | .0020750 | 107,200 | 15.75 | 44.85 | ........ | ....... |
| 8 | 20 | $D_2$ | .......... | 1 | Outside. | 57,000 | .0019625 | 102,000 | 16.00 | 42.72 | ........ | ....... |
| 8 | 20 | $D_2$ | .......... | 2 | Middle . | 53,000 | .0018500 | 103,200 | 15.875 | 41.37 | ........ | ....... |
| 8 | 20 | $D_2$ | .......... | 3 | Inside .. | 57,000 | .0018500 | 105,200 | 15.375 | 46.41 | ........ | ....... |
| 8 | 22 | $D_2$ | .......... | 1 | Outside. | 63,000 | .0021750 | 110,000 | 17.50 | 46.15 | ........ | ....... |
| 8 | 22 | $D_2$ | .......... | 2 | Middle . | 63,000 | .0021625 | 111,200 | 15.50 | 40.28 | ........ | ....... |
| 8 | 22 | $D_2$ | .......... | 3 | Inside .. | 64,000 | .0021875 | 110,000 | 14.25 | 37.23 | ........ | ....... |
| 8 | 24 | $D_2$ | .......... | 1 | Outside. | 67,000 | .0022125 | 110,800 | 15.75 | 42.72 | ........ | ....... |
| 8 | 24 | $D_2$ | .......... | 2 | Middle . | 64,000 | .0022250 | 110,800 | 15.25 | 39.45 | ........ | ....... |
| 8 | 24 | $D_2$ | .......... | 3 | Inside .. | 66,000 | .0022750 | 110,800 | 12.75 | 23.95 | ........ | ....... |
| 10 | 2 | $D_2$ | Muzzle . | 1 | Middle . | 58,000 | .0019375 | 107,200 | 16.75 | 44.32 | ........ | ....... |
| 10 | 2 | $D_2$ | ....do ... | 2 | ....do ... | 57,000 | .0019375 | 107,600 | 15.125 | 42.45 | ........ | ....... |
| 10 | 2 | $D_2$ | ....do ... | 3 | ....do ... | 55,000 | .0018500 | 105,600 | 16.75 | 44.32 | ........ | ....... |
| 10 | 2 | $D_2$ | Breech .. | 1 | Outside. | 57,000 | .0019250 | 107,600 | 14.875 | 41.91 | ........ | ....... |
| 10 | 2 | $D_2$ | ....do ... | 2 | Middle . | 54,000 | .0018125 | 102,800 | 14.125 | 33.81 | ........ | ....... |
| 10 | 2 | $D_2$ | ....do ... | 3 | Inside .. | 56,000 | .0019625 | 108,800 | 13.00 | 39.18 | ........ | ....... |
| 10 | 3 | $D_2$ | Muzzle . | 1 | Middle . | 55,000 | .0019125 | 109,200 | 14.25 | 38.90 | ........ | ....... |
| 10 | 3 | $D_2$ | ....do ... | 2 | ....do ... | 59,000 | .0020750 | 108,400 | 14,875 | 39.18 | ........ | ....... |
| 10 | 3 | $D_2$ | ....do ... | 3 | ....do ... | 59,000 | .0020375 | 111,600 | 14.75 | 37.79 | ........ | ....... |
| 10 | 3 | $D_2$ | Breech .. | 1 | Outside. | 59,000 | .0020875 | 109,200 | 15.875 | 35.25 | ........ | ....... |
| 10 | 3 | $D_2$ | ....do ... | 2 | Middle . | 53,000 | .0018500 | 104,000 | 18.25 | 38.90 | ........ | ....... |
| 10 | 3 | $D_2$ | ....do ... | 3 | Inside .. | 58,000 | .0020500 | 109,200 | 16.75 | 41.91 | ........ | ....... |
| 12 | 2 | $D_2$ | Muzzle . | 1 | Outside. | 60,000 | .0021500 | 112,000 | 14.625 | 41.37 | ........ | ....... |
| 12 | 2 | $D_2$ | ....do ... | 2 | Middle . | 64.000 | .0021750 | 112,800 | 14.375 | 44.58 | ........ | ....... |
| 12 | 2 | $D_2$ | ....do ... | 3 | Inside .. | 64,000 | .0022875 | 115,600 | 15.25 | 44.05 | ........ | ....... |
| 12 | 2 | $D_2$ | Breech .. | 1 | Outside. | 61,000 | .0021375 | 111,000 | 14.75 | 43.02 | ........ | ....... |
| 12 | 2 | $D_2$ | ....do ... | 2 | Middle . | 59,000 | .0021125 | 108,400 | 15.125 | 37.23 | ........ | ....... |
| 12 | 2 | $D_2$ | ....do ... | 3 | Inside .. | 64,000 | .0023375 | 114,000 | 13.125 | 34.39 | ........ | ....... |
| 8 | 3 | $D_3$ | .......... | 1 | Outside. | 62,000 | .0021375 | 106,800 | 16.25 | 44.05 | ........ | ....... |
| 8 | 3 | $D_3$ | .......... | 2 | Middle . | 58,000 | .0020750 | 106,800 | 16.875 | 43.79 | ........ | ....... |
| 8 | 3 | $D_3$ | .......... | 3 | Inside .. | 60,000 | .0020875 | 100,800 | 15.75 | 43.79 | ........ | ....... |
| 8 | 4 | $D_3$ | .......... | 1 | ....do ... | 61,000 | .0021375 | 108.400 | 17.80 | 67.01 | ........ | ....... |
| 8 | 4 | $D_3$ | .......... | 2 | Outside. | 62,000 | .0021875 | 104,800 | 15.65 | 41.37 | ........ | ....... |
| 8 | 4 | $D_3$ | .......... | 3 | Middle . | 60,000 | .0020875 | 104,700 | 13.275 | 21.39 | ........ | ....... |
| 8 | 7 | $D_3$ | .......... | 1 | Outside. | 55,000 | .0018875 | 108.000 | 14.375 | 37.23 | ........ | ....... |
| 8 | 7 | $D_3$ | .......... | 2 | Inside .. | 53,000 | .0019000 | 106,000 | 14.75 | 36.94 | ........ | ....... |
| 8 | 7 | $D_3$ | .......... | 3 | Middle . | 53,000 | .0019125 | 105,200 | 14.625 | 34.96 | ........ | ....... |
| 8 | 8 | $D_3$ | .......... | 1 | Outside. | 61,000 | .0020750 | 103,600 | 17.75 | 46.15 | ........ | ....... |
| 8 | 8 | $D_3$ | .......... | 2 | Middle . | 60,000 | .0020875 | 110,000 | 15.125 | 40.83 | ........ | ....... |
| 8 | 8 | $D_3$ | .......... | 3 | Inside .. | 60,000 | .0020875 | 109,600 | 13.25 | 37.23 | ........ | ....... |
| 8 | 10 | $D_3$ | .......... | 1 | Outside. | 61,000 | .0021000 | 111,200 | 16.25 | 39.18 | ........ | ....... |
| 8 | 10 | $D_3$ | .......... | 2 | Middle . | 55,000 | .0019000 | 108,800 | 14.75 | 35.25 | ........ | ....... |
| 8 | 10 | $D_3$ | .......... | 3 | Inside .. | 62,000 | .0020625 | 111,600 | 17.00 | 41.91 | ........ | ....... |
| 8 | 12 | $D_3$ | .......... | 1 | .... do... | 60,000 | .0020875 | 100,000 | 15.75 | 50.98 | ........ | ....... |
| 8 | 12 | $D_3$ | .......... | 2 | Middle . | 59,000 | .0021125 | 100,000 | 18.375 | 41.64 | ........ | ....... |
| 8 | 12 | $D_3$ | .......... | 3 | Outside. | 56,000 | .0020375 | 97,600 | 20.875 | 47.45 | ........ | ....... |
| 8 | 14 | $D_3$ | .......... | 1 | Inside .. | 56,000 | .0019250 | 98,000 | 16.75 | 46.67 | ........ | ....... |
| 8 | 14 | $D_3$ | .......... | 2 | Middle . | 55,000 | .0019750 | 95,600 | 18.25 | 46.67 | ........ | ....... |
| 8 | 14 | $D_3$ | .......... | 3 | Outside. | 56,000 | .0019625 | 99,200 | 16.25 | 45.63 | ........ | ....... |
| 8 | 16 | $D_3$ | .......... | 1 | ....do ... | 55,000 | .0018875 | 102,400 | 16.875 | 42.18 | ........ | ....... |
| 8 | 16 | $D_3$ | .......... | 2 | Middle . | 55,000 | .0018625 | 101,600 | 15.50 | 21.15 | ........ | ....... |
| 8 | 16 | $D_3$ | .......... | 3 | Inside .. | 56,000 | .0019125 | 103,200 | 15.125 | 48.98 | ........ | ....... |
| 8 | 18 | $D_3$ | .......... | 1 | Outside. | 57,000 | .0019750 | 108,000 | 16.125 | 37.23 | ........ | ....... |
| 8 | 18 | $D_3$ | .......... | 2 | Middle . | 57,000 | .0019500 | 108,000 | 16.625 | 43.52 | ........ | ....... |
| 8 | 18 | $D_3$ | .......... | 3 | Inside .. | 58,000 | .0019000 | 108,000 | 18.00 | 46.15 | ........ | ....... |
| 8 | 20 | $D_3$ | .......... | 1 | Outside. | 54,000 | .0018750 | 105,600 | 14.375 | 36.67 | ........ | ....... |
| 8 | 20 | $D_3$ | .......... | 2 | Middle . | 52,000 | .0018250 | 104,000 | 16.75 | 36.94 | ........ | ....... |
| 8 | 20 | $D_3$ | .......... | 3 | Inside .. | 54,000 | .0018625 | 106,400 | 13.875 | 35.53 | ........ | ....... |
| 8 | 22 | $D_3$ | .......... | 1 | Middle . | 54,000 | .0019125 | 104,000 | 18.875 | 40.00 | ........ | ....... |
| 8 | 22 | $D_3$ | .......... | 2 | Inside .. | 56,000 | .0019250 | 105,600 | 18.00 | 42.99 | ........ | ....... |
| 8 | 22 | $D_3$ | .......... | 3 | Middle . | 54,000 | .0019250 | 102,400 | 16.375 | 42.18 | ........ | ....... |
| 10 | 2 | $C_1$ | .......... | 1 | Outside. | 57,000 | .0019500 | 110,600 | 15.375 | 36.94 | ........ | ....... |
| 10 | 2 | $C_1$ | .......... | 2 | Inside .. | 59,000 | .0019875 | 111,200 | 15.25 | 36.38 | ........ | ....... |
| 10 | 2 | $C_1$ | .......... | 3 | Middle . | 54,000 | .0018375 | 108,400 | 17.25 | 36.67 | ........ | ....... |
| 12 | 2 | $C_2$ | .......... | 1 | Outside. | 62,000 | .0021500 | 112,000 | 21.33 | 46.41 | ........ | ....... |
| 12 | 2 | $C_2$ | .......... | 2 | Middle . | 61,000 | .0021375 | 108,800 | 14.75 | 40.28 | ........ | ....... |
| 12 | 2 | $C_2$ | .......... | 3 | Inside .. | 64,000 | .0022375 | 108,400 | 16.00 | 50.24 | ........ | ....... |
| 10 | 2 | $C_2$ | .......... | 1 | ....do ... | 62,000 | .0022500 | 108,800 | 12.325 | 27.32 | ........ | ....... |

*Results of tensile tests of tangential specimens from hoops for 8-inch, 10-inch, and 12-inch B. L. rifles*—Continued.

| Caliber. | Number of gun. | Mark of hoop. | Breech or muzzle. | Number of specimen. | Position of specimen. | Elastic limit per square inch of original section. | Elongation per inch under strain at elastic limit. | Tensile strength per square inch of original section. | Elongation after rupture. | Reduction of area after rupture. | Specific gravity. | Hardness. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Pounds.* | *Inch.* | *Pounds.* | *Per ct.* | *Per ct.* | | |
| 10 | 2 | $C_2$ | .......... | 2 | Outside. | 63,000 | .0022000 | 106,800 | 15.625 | 43.79 | ........ | ....... |
| 10 | 2 | $C_2$ | .......... | 3 | Middle . | 60,000 | .0021250 | 106,000 | 15.975 | 41.37 | ........ | ....... |
| 10 | 3 | $C_2$ | .......... | 1 | Outside. | 56,000 | .0018625 | 115,200 | 14.00 | 34.10 | ........ | ....... |
| 10 | 3 | $C_2$ | .......... | 2 | Middle . | 59,000 | .0019750 | 114,400 | 13.75 | 32.65 | ........ | ....... |
| 10 | 3 | $C_2$ | .......... | 3 | Inside . | 57,000 | .0019250 | 113,600 | 13.50 | 32.94 | ........ | ....... |
| 10 | 4 | $C_3$ | .......... | 1 | Outside. | 58,000 | .0019875 | 104,800 | 17.50 | 43.25 | ........ | ....... |
| 10 | 4 | $C_3$ | .......... | 2 | Inside .. | 56,000 | .0018500 | 102,400 | 16.375 | 21.77 | ........ | ....... |
| 10 | 4 | $C_3$ | .......... | 3 | Middle . | 55,000 | .0019125 | 102,000 | 16.75 | 40.83 | ........ | ....... |
| 10 | 5 | $C_3$ | .......... | 1 | Inside .. | 58,000 | .0020000 | 106,000 | 15.50 | 32.65 | ........ | ....... |
| 10 | 5 | $C_3$ | .......... | 2 | Middle . | 56,000 | .0019750 | 104,000 | 14.25 | 36.67 | ........ | ....... |
| 10 | 5 | $C_3$ | .......... | 3 | Outside. | 56,000 | .0020125 | 108,400 | 14.75 | 38.35 | ........ | ....... |
| 12 | 2 | $C_3$ | .......... | 1 | Middle . | 55,000 | .0019750 | 107,200 | 15.00 | 34.68 | ........ | ....... |
| 12 | 2 | $C_3$ | .......... | 2 | Inside .. | 55,000 | .0019625 | 108,000 | 15.25 | 34.68 | ........ | ....... |
| 12 | 2 | $C_3$ | .......... | 3 | Outside. | 55,000 | .0019500 | 106,000 | 16.00 | 39.73 | ........ | ....... |
| 10 | 2 | $C_4$ | Muzzle . | 1 | ....do ... | 56,000 | .0020125 | 98,800 | 18.50 | 48.47 | ........ | ....... |
| 10 | 2 | $C_4$ | ....do ... | 2 | Inside .. | 57,000 | .0019625 | 100,000 | 20.00 | 49.99 | ........ | ....... |
| 10 | 2 | $C_4$ | ....do ... | 3 | Middle . | 54,000 | .0019125 | 98,400 | 21.50 | 47.19 | ........ | ....... |
| 10 | 2 | $C_4$ | Breech.. | 1 | Outside. | 58,000 | .0021250 | 101,600 | 18.375 | 46.67 | ........ | ....... |
| 10 | 2 | $C_4$ | ....do ... | 2 | Middle . | 55,000 | .0019875 | 101,200 | 17.00 | 44.85 | ........ | ....... |
| 10 | 2 | $C_4$ | ....do ... | 3 | Inside .. | 57,000 | .0020500 | 102,800 | 17.25 | 49.23 | ........ | ....... |
| 12 | 2 | $C_4$ | Muzzle . | 1 | Outside. | 64,000 | .0022625 | 105,600 | 17.00 | 45.89 | ........ | ....... |
| 12 | 2 | $C_4$ | ....do .. | 2 | Middle . | 59,000 | .0020500 | 104,600 | 16.75 | 47.71 | ........ | ....... |
| 12 | 2 | $C_4$ | ....do ... | 3 | Inside .. | 61,000 | .0021375 | 106,400 | 15.75 | 46.41 | ........ | ....... |
| 12 | 2 | $C_4$ | Breech.. | 1 | Outside. | 60,000 | .0020375 | 107,200 | 14.50 | 32.65 | ........ | ....... |
| 12 | 2 | $C_4$ | ....do ... | 2 | Inside .. | 64,000 | .0022375 | 110,400 | 14.25 | 43.25 | ........ | ....... |
| 12 | 2 | $C_4$ | ....do ... | 3 | Middle . | 59,000 | .0020000 | 106,800 | 15.75 | 43.52 | ........ | ....... |
| 12 | 2 | $C_5$ | Muzzle.. | 1 | Outside. | 56,000 | .0018375 | 106,000 | 15.75 | 41.91 | ........ | ....... |
| 12 | 2 | $C_5$ | ....do ... | 2 | Middle . | 54,000 | .0017250 | 103,200 | 17.375 | 43.25 | ........ | ....... |
| 12 | 2 | $C_5$ | ....do ... | 3 | Inside .. | 57,000 | .0019125 | 107,600 | 16.75 | 46.15 | ........ | ....... |
| 12 | 2 | $C_5$ | Breech.. | 1 | Outside. | 56,000 | .0018250 | 102,800 | 15.75 | 42.99 | ........ | ....... |
| 12 | 2 | $C_5$ | ....do ... | 2 | Inside .. | 56,000 | .0018375 | 105,200 | 16.75 | 43.79 | ........ | ....... |
| 12 | 2 | $C_5$ | ....do ... | 3 | Middle . | 55,000 | .0018875 | 102,000 | 17.50 | 41.64 | ........ | ....... |
| 12 | 3 | $C_5$ | Muzzle . | 1 | Outside. | 62,000 | .0022250 | 111,200 | 15.125 | 40.83 | ........ | ....... |
| 12 | 3 | $C_5$ | ....do ... | 2 | Middle . | 58,000 | .0020750 | 111,200 | 15.50 | 35.25 | ........ | ....... |
| 12 | 3 | $C_5$ | ....do ... | 3′ | Inside .. | 65,000 | .0023250 | 114,800 | 16.875 | 40.55 | ........ | ....... |
| 12 | 3 | $C_5$ | Breech.. | 1 | Outside. | 66,000 | .0023750 | 115,600 | 14.375 | 34.39 | ........ | ....... |
| 12 | 3 | $C_5$ | ....do ... | 2 | Middle . | 62,000 | .0022250 | 110,800 | 13.875 | 40.28 | ........ | ....... |
| 12 | 3 | $C_5$ | ....do ... | 3 | ....do ... | 59,000 | .0021000 | 110,000 | 12.50 | 15.96 | ........ | ....... |
| 12 | 2 | $C_6$ | Muzzle . | 1 | Outside. | 62,000 | .0022125 | 105,200 | 16.50 | 46.41 | ........ | ....... |
| 12 | 2 | $C_6$ | ....do ... | 2 | Middle . | 59,000 | .0020375 | 104,000 | 18.00 | 45.63 | ........ | ....... |
| 12 | 2 | $C_6$ | ....do ... | 3 | Inside .. | 59,000 | .0020625 | 105,600 | 15.25 | 44.58 | ........ | ....... |
| 12 | 2 | $C_6$ | Breech.. | 1 | Outside. | 58,000 | .0019500 | 104,400 | 15.25 | 38.62 | ........ | ....... |
| 12 | 2 | $C_6$ | ....do ... | 2 | Middle . | 57,000 | .0019250 | 104,000 | 16.50 | 40.83 | ........ | ....... |
| 12 | 2 | $C_6$ | ....do ... | 3 | Inside .. | 60,000 | .0021750 | 106,400 | 14.75 | 38.90 | ........ | ....... |
| 12 | 2 | $C_7$ | Muzzle . | 1 | Middle . | 60,000 | .0020375 | 112,000 | 14.50 | 38.62 | ........ | ....... |
| 12 | 2 | $C_7$ | ....do ... | 2 | ....do ... | 63,000 | .0022125 | 110,800 | 16.25 | 41.10 | ........ | ....... |
| 12 | 2 | $C_7$ | ....do ... | 3 | ....do ... | 60,000 | .0020625 | 108,000 | 13.50 | 34.68 | ........ | ....... |
| 12 | 2 | $C_7$ | Breech.. | 1 | ....do ... | 61,000 | .0017500 | 114,000 | 14.50 | 34.10 | ........ | ....... |
| 12 | 2 | $C_7$ | ....do ... | 2 | ....do ... | 62,000 | .0021250 | 113,600 | 15.125 | 39.73 | ........ | ....... |
| 12 | 2 | $C_7$ | ....do ... | 3 | ....do ... | 61,000 | .0020875 | 114,400 | 12.50 | 34.68 | ........ | ....... |

*Results of tensile tests of tangential specimens from hoops for 8-inch and 10-inch B. L. rifles.*

[Length of specimen, 3 inches; sectional area, 0.25 square inch.]

| Caliber. | Number of hoop. | Mark of hoop. | Breech or muzzle. | Number of specimen. | Position of specimen. | Elastic limit per square inch of original section. | Elongation per inch under strain at elastic limit. | Tensile strength per square inch of original section. | Elongation after rupture. | Reduction of area after rupture. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Pounds.* | *Inch.* | *Pounds.* | *Per ct.* | *Per ct.* |
| 8 | 5 | $C_1$ | | 1 | Outside | 60,000 | .002167 | 104,800 | 17.67 | 42.99 |
| 8 | 5 | $C_1$ | | 2 | Middle | 54,000 | .001967 | 103,200 | 18.33 | 33.52 |
| 8 | 7 | $C_1$ | | 1 | Outside | 57.000 | .002050 | 109,200 | 15.33 | 43.25 |
| 8 | 7 | $C_1$ | | 2 | Middle | 53,000 | .001950 | 107,177 | 15.00 | 33.29 |
| 8 | 8 | $C_1$ | | 1 | Outside | 58,000 | .002117 | 109,200 | 16.33 | 45.89 |
| 8 | 8 | $C_1$ | | 2 | Middle | 58,000 | .002150 | 109,200 | 15.83 | 37.79 |
| 8 | 10 | $C_1$ | | 1 | Outside | 57,000 | .001900 | 109,600 | 17.67 | 36.10 |
| 8 | 10 | $C_1$ | | 2 | Middle | 53,000 | .001950 | 106,400 | 16.83 | 29.71 |
| 8 | *11 | $C_1$ | | 1 | Outside | 59,000 | | 108,800 | 15.33 | 34.39 |
| 8 | *11 | $C_1$ | | 2 | Middle | 60,000 | | 112,000 | 14.00 | 19.95 |
| 8 | 11 | $C_1$ | | 3 | Outside | 56,000 | .002033 | 105,600 | 17.17 | 41.91 |
| 8 | 11 | $C_1$ | | 4 | Middle | 54,000 | .002050 | 108,400 | 16.33 | 34.68 |
| 8 | 14 | $C_1$ | | 1 | do | 58,000 | .002083 | 106,000 | 16.67 | 31.78 |
| 8 | 14 | $C_1$ | | 2 | do | 56,000 | .001900 | 106,000 | 16.50 | 26.10 |
| 8 | 16 | $C_1$ | | 1 | Outside | 60,000 | .002483 | 106,400 | 18.33 | 43.25 |
| 8 | 16 | $C_1$ | | 2 | Middle | 56,000 | .001983 | 100,400 | 18.33 | 40.55 |
| 8 | 18 | $C_1$ | | 1 | do | 58,000 | .001967 | 108,000 | 16.33 | 40.83 |
| 8 | 18 | $C_1$ | | 2 | do | 55,000 | .001850 | 102,000 | 18.00 | 45.37 |
| 8 | 21 | $C_1$ | | 1 | do | 61,000 | .002183 | 115,200 | 15.33 | 32.65 |
| 8 | 21 | $C_1$ | | 2 | do | 59,000 | .002068 | 109,600 | 16.33 | 39.73 |
| 8 | 22 | $C_1$ | | 3 | do | 60,000 | .001983 | 112,000 | 17.00 | 36.10 |
| 8 | 22 | $C_1$ | | 4 | do | 57,000 | .001933 | 104,800 | 16.17 | 36.38 |
| 8 | 24 | $C_1$ | | 1 | do | 58,000 | .002050 | 110,800 | 16.33 | 36.10 |
| 8 | 24 | $C_1$ | | 2 | do | 54,000 | .001900 | 106,800 | 16.67 | 37.51 |
| 8 | 13 | $C_2$ | | 1 | do | 61,000 | .002283 | 107,600 | 15.67 | 36.38 |
| 8 | 13 | $C_2$ | | 2 | do | 59,000 | .002183 | 106,800 | 17.00 | 31.19 |
| 8 | †15 | $C_2$ | | 1 | Outside | 53,000 | | 105,600 | 17.33 | 46.15 |
| 8 | †15 | $C_2$ | | 2 | Middle | 55,000 | | 107,200 | 10.50 | 22.09 |
| 8 | 15 | $C_2$ | | 3 | Outside | 57,000 | .001983 | 104,400 | 16.33 | 34.10 |
| 8 | 15 | $C_2$ | | 4 | Middle | 55,000 | .001900 | 104,800 | 17.67 | 28.82 |
| 8 | 17 | $C_2$ | | 1 | Outside | 64,000 | .002217 | 119,600 | 16.17 | 34.98 |
| 8 | 17 | $C_2$ | | 2 | Middle | 64,000 | .002233 | 118,000 | 15.33 | 38.35 |
| 8 | 19 | $C_2$ | | 1 | Outside | 66,000 | .002450 | 113,600 | 16.33 | 39.73 |
| 8 | 19 | $C_2$ | | 2 | Middle | 62,000 | .002250 | 108,800 | 17.33 | 40.28 |
| 8 | *22 | $C_2$ | | 1 | Outside | 60,000 | | 115,200 | 14.33 | 32.65 |
| 8 | *22 | $C_2$ | | 2 | Middle | 63,000 | | 116,400 | 14.17 | 34.96 |
| 8 | 22 | $C_2$ | | 3 | Outside | 56,000 | .001967 | 109,200 | 15.33 | 35.25 |
| 8 | 22 | $C_2$ | | 4 | Middle | 59,000 | .002117 | 109,200 | 20.67 | 43.52 |
| 8 | 23 | $C_2$ | | 1 | Outside | 55,000 | .001850 | 96,400 | 16.33 | 48.22 |
| 8 | 23 | $C_2$ | | 2 | Middle | 58,000 | .002033 | 98,400 | 16.33 | 44.32 |
| 8 | 10 | $C_3$ | Muzzle | 1 | Outside | 58,000 | .002100 | 104,400 | 16.00 | 34.10 |
| 8 | 10 | $C_3$ | do | 2 | Middle | 54,000 | .001917 | 103,200 | 17.67 | 38.35 |
| 8 | 10 | $C_3$ | Breech | 1 | Outside | 56,000 | .002083 | 102,800 | 17.50 | 38.62 |
| 8 | 10 | $C_3$ | do | 2 | Middle | 57,000 | .002033 | 105,200 | 15.33 | 36.07 |
| 8 | ‡12 | $C_3$ | Muzzle | 1 | Outside | 63,000 | | 116,000 | 14.50 | 37.79 |
| 8 | ‡12 | $C_3$ | do | 2 | Middle | 62,000 | | 115,600 | 15.33 | 37.23 |
| 8 | ‡12 | $C_3$ | Breech | 1 | Outside | 61,000 | | 108,400 | 17.50 | 42.72 |
| 8 | ‡12 | $C_3$ | do | 2 | Middle | 50,000 | | 99,200 | 19.50 | 36.07 |
| 8 | 12 | $C_3$ | Muzzle | 3 | Outside | 68,000 | .002333 | 115,200 | 17.17 | 44.32 |
| 8 | 12 | $C_3$ | do | 4 | Middle | 73,000 | .002583 | 120,400 | 14.00 | 36.38 |
| 8 | 12 | $C_3$ | Breech | 3 | Outside | 63,000 | .002183 | 117,600 | 16.67 | 37.79 |
| 8 | 12 | $C_3$ | do | 4 | Middle | 60,000 | .002217 | 116,000 | 15.67 | 34.68 |
| 8 | *14 | $C_3$ | Muzzle | 1 | Outside | 65,000 | | 119,200 | 13.67 | 33.81 |
| 8 | *14 | $C_3$ | do | 2 | Middle | 62,000 | | 116,400 | 14.50 | 33.81 |
| 8 | *14 | $C_3$ | Breech | 1 | Outside | 62,000 | | 114,400 | 15.33 | 38.90 |
| 8 | *14 | $C_3$ | do | 2 | Middle | 58,000 | | 114,200 | 14.00 | 33.81 |
| 8 | 14 | $C_3$ | Muzzle | 3 | Outside | 62,000 | .002217 | 111,600 | 17.83 | 47.70 |
| 8 | 14 | $C_3$ | do | 4 | Middle | 56,000 | .002050 | 113,200 | 15.33 | 40.55 |
| 8 | 14 | $C_3$ | Breech | 3 | Outside | 54,000 | .002000 | 110,400 | 15.00 | 43.52 |
| 8 | 14 | $C_3$ | do | 4 | Middle | 54,000 | .001917 | 108,200 | 15.00 | 40.28 |
| 8 | 16 | $C_3$ | Muzzle | 1 | Outside | 65,000 | .002250 | 119,200 | 14.67 | 24.88 |
| 8 | 16 | $C_3$ | do | 2 | Middle | 59,000 | .002050 | 108,400 | 16.50 | 31.19 |
| 8 | 16 | $C_3$ | do | 3 | Outside | 59,000 | .002133 | 113,600 | 15.17 | 34.68 |
| 8 | 16 | $C_3$ | do | 4 | Middle | 58,000 | .001983 | 112,000 | 16.00 | 37.23 |

* Not accepted on these results; reannealed.
† Not accepted on these results; retested.
‡ Not accepted on these results; retempered and annealed.

*Results of tensile tests of tangential specimens from hoops for 8-inch and 10-inch B. L. rifles*—Continued.

| Caliber. | Number of hoop. | Mark of hoop. | Breech or muzzle. | Number of specimen. | Position of specimen. | Elastic limit per square inch of original section. | Elongation per inch under strain at elastic limit. | Tensile strength per square inch of original section. | Elongation after rupture. | Reduction of area after rupture. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Pounds.* | *Inch.* | *Pounds.* | *Per ct.* | *Per ct.* |
| 8 | 16 | $C_3$ | Breech ..... | 1 | Outside ..... | 59,000 | .002067 | 111,200 | 14.33 | 32.36 |
| 8 | 16 | $C_3$ | ....do ....... | 2 | Middle ...... | 57,000 | .002017 | 113,600 | 16.33 | 37.51 |
| 8 | 17 | $C_3$ | Muzzle ..... | 1 | Outside ..... | 63,000 | .002183 | 114,000 | 15.66 | 40.28 |
| 8 | 17 | $C_3$ | ....do ....... | 2 | Middle ...... | 58,000 | .002083 | 111,200 | 14.67 | 25.18 |
| 8 | 17 | $C_3$ | Breech ..... | 1 | Outside ..... | 62,000 | .002200 | 110,000 | 18.67 | 42.18 |
| 8 | 17 | $C_3$ | ....do ....... | 2 | Middle ...... | 59,000 | .002133 | 109,600 | 17.17 | 41.37 |
| 8 | 20 | $C_3$ | Muzzle ..... | 1 | Outside ..... | 65,000 | .002283 | 111,600 | 15.83 | 41.91 |
| 8 | 20 | $C_3$ | ....do ....... | 2 | Middle ...... | 59,000 | .002100 | 112,800 | 15.67 | 31.19 |
| 8 | 20 | $C_3$ | Breech ..... | 1 | Outside ..... | 34,000 | .002267 | 118,400 | 14.67 | 37.23 |
| 8 | 20 | $C_3$ | ....do ....... | 2 | Middle ...... | 59,000 | .002100 | 108,000 | 17.00 | 39.73 |
| 8 | *21 | $C_3$ | Muzzle ..... | 1 | Outside ..... | 57,000 | ............ | 102,400 | 18.50 | 42.99 |
| 8 | *21 | $C_3$ | ....do ....... | 2 | Middle ...... | 53,000 | ............ | 103,200 | 18.17 | 38.90 |
| 8 | *21 | $C_3$ | Breech ..... | 1 | Outside ..... | 55,000 | ............ | 102,000 | 7.33 | 8.64 |
| 8 | *21 | $C_3$ | ....do ....... | 2 | Middle ...... | 51,000 | ............ | 95,600 | 18.50 | 32.07 |
| 8 | 21 | $C_3$ | Muzzle ..... | 3 | ....do ....... | 57,000 | .001983 | 111,600 | 14.00 | 34.68 |
| 8 | 21 | $C_3$ | ....do ....... | 4 | ....do ....... | 61,000 | .002117 | 101,600 | 18.83 | 44.32 |
| 8 | 21 | $C_3$ | Breech ..... | 3 | ....do ....... | 58,000 | .002017 | 100,400 | 15.00 | 19.65 |
| 8 | 21 | $C_3$ | ....do ....... | 4 | ....do ....... | 53,000 | .001800 | 101,200 | 18.83 | 42.99 |
| 8 | *23 | $C_3$ | Muzzle ..... | 1 | ....do ....... | 54,000 | ............ | 98,800 | 19.67 | 42.99 |
| 8 | *23 | $C_3$ | ....do ....... | 2 | ....do ....... | 52,000 | ............ | 97,600 | 20.83 | 38.35 |
| 8 | *23 | $C_3$ | Breech ..... | 1 | ....do ....... | 53,000 | ............ | 104,000 | 18.83 | 40.55 |
| 8 | *23 | $C_3$ | ....do ....... | 2 | ....do ....... | 56,000 | ............ | 102,000 | 18.33 | 43.52 |
| 8 | 23 | $C_3$ | Muzzle ..... | 3 | ....do ....... | 58,000 | .002000 | 106,000 | 15.33 | 36.94 |
| 8 | 23 | $C_3$ | ....do ....... | 4 | ....do ....... | 55,000 | .001767 | 103,200 | 16.50 | 41.91 |
| 8 | 23 | $C_3$ | Breech ...... | 3 | ....do ....... | 58,880 | .002167 | 106,800 | 16.33 | 40.20 |
| 8 | 3 | $C_4$ | ............... | 3 | Outside ..... | 57,000 | .002067 | 104,000 | 18.67 | 41.64 |
| 8 | 3 | $C_4$ | ............... | 4 | Middle ...... | 56,000 | .002033 | 104,000 | 17.33 | 40.00 |
| 8 | 5 | $C_4$ | ............... | 1 | ....do ....... | 57,000 | .002067 | 110,400 | 15.17 | 33.23 |
| 8 | 6 | $C_4$ | ............... | 1 | ....do ....... | 59,000 | .002100 | 110,800 | 15.33 | 36.94 |
| 8 | 6 | $C_4$ | ............... | 2 | ....do ....... | 62,000 | .002300 | 115,200 | 12.67 | 19.66 |
| 8 | 12 | $C_4$ | ............... | 1 | Outside ..... | 60,000 | .002117 | 110,400 | 16.50 | 38.62 |
| 8 | 12 | $C_4$ | ............... | 2 | Middle ..... | 62,000 | .002217 | 112,800 | 17.50 | 38.90 |
| 8 | 14 | $C_4$ | ............... | 1 | Outside ..... | 63,000 | .002183 | 105,600 | 17.17 | 40.55 |
| 8 | 14 | $C_4$ | ............... | 2 | Middle ..... | 57,000 | .001917 | 104,800 | 17.83 | 40.55 |
| 8 | 16 | $C_4$ | ............... | 1 | ....do ....... | 60,000 | .002100 | 110,400 | 18.00 | 39.73 |
| 8 | 16 | $C_4$ | ............... | 2 | ....do ....... | 64,000 | .002283 | 114,800 | 16.33 | 37.23 |
| 8 | 17 | $C_4$ | ............... | 1 | ....do ....... | 55,000 | .001867 | 98,400 | 17.00 | 35.82 |
| 8 | 17 | $C_4$ | ............... | 2 | ....do ....... | 54,000 | .001900 | 101,600 | 16.00 | 37.51 |
| 8 | 19 | $C_4$ | ............... | 1 | ....do ....... | 59,000 | .002033 | 110,400 | 16.33 | 34.39 |
| 8 | 19 | $C_4$ | ............... | 2 | ....do ....... | 56,000 | .001933 | 110,000 | 16.67 | 36.94 |
| 8 | 22 | $C_4$ | ............... | 1 | ....do ....... | 61,000 | .002200 | 110,000 | 17.33 | 41.10 |
| 8 | 22 | $C_4$ | ............... | 2 | ....do ....... | 61,000 | .002067 | 112,000 | 17.00 | 36.38 |
| 8 | †9 | $C_5$ | ............... | 1 | Outside ..... | 59,000 | ............ | 109,600 | 15.00 | 31.49 |
| 8 | †9 | $C_5$ | ............... | 2 | Middle ...... | 59,000 | ............ | 108,400 | 13.67 | 21.14 |
| 8 | *9 | $C_5$ | ............... | 3 | ....do ....... | 56,000 | ............ | 103,200 | 17.83 | 38.90 |
| 8 | *9 | $C_5$ | ............... | 4 | ....do ....... | 51,000 | ............ | 103,200 | 16.00 | 27.92 |
| 8 | 9 | $C_5$ | ............... | 5 | ....do ....... | 59,000 | .001917 | 110,000 | 18.00 | 40.28 |
| 8 | 9 | $C_5$ | ............... | 6 | ....do ....... | 60,000 | .002033 | 111,600 | 18.33 | 42.72 |
| 8 | 10 | $C_5$ | ............... | 1 | ....do ....... | 61,000 | .002133 | 112,000 | 15.50 | 38.35 |
| 8 | 10 | $C_5$ | ............... | 2 | ....do ....... | 60,000 | .002200 | 109,600 | 16.50 | 40.55 |
| 8 | 12 | $C_5$ | ............... | 1 | Outside ..... | 57,000 | .001983 | 106,400 | 16.83 | 49.23 |
| 8 | 12 | $C_5$ | ............... | 2 | Middle ..... | 57,000 | .001983 | 108,000 | 17.50 | 44.05 |
| 8 | 13 | $C_5$ | ............... | 1 | Outside ..... | 56,000 | .002033 | 104,400 | 17.50 | 39.45 |
| 8 | 13 | $C_5$ | ............... | 2 | Middle ..... | 53,000 | .001867 | 102,400 | 17.83 | 42.72 |
| 8 | 15 | $C_5$ | ............... | 1 | Outside ..... | 58,000 | .001983 | 104,400 | 16.67 | 40.00 |
| 8 | 15 | $C_5$ | ............... | 2 | Middle ...... | 60,000 | .002050 | 103,200 | 20.33 | 41.91 |
| 8 | 17 | $C_5$ | ............... | 1 | ....do ....... | 61,000 | .002033 | 105,200 | 20.50 | 42.99 |
| 8 | 17 | $C_5$ | ............... | 2 | ....do ....... | 61,000 | .002100 | 108,400 | 20.00 | 40.00 |
| 8 | 22 | $C_5$ | ............... | 1 | ....do ....... | 63,000 | .002117 | 116,200 | 16.50 | 39.45 |
| 8 | 22 | $C_5$ | ............... | 2 | ....do ....... | 57,000 | .001867 | 110,800 | 18.00 | 41.10 |
| 8 | 23 | $C_5$ | ............... | 1 | ....do ....... | 58,000 | .001950 | 104,400 | 18.00 | 44.05 |
| 8 | 23 | $C_5$ | ............... | 2 | ....do ....... | 57,000 | .001933 | 105,600 | 17.67 | 42.72 |
| 8 | 24 | $C_5$ | ............... | 1 | ....do ....... | 62,000 | .002083 | 104,400 | 18.33 | 40.83 |
| 8 | 24 | $C_5$ | ............... | 2 | ....do ....... | 56,000 | .001817 | 102,400 | 17.33 | 43.79 |
| 10 | *2 | $C_5$ | Muzzle ..... | 1 | ....do ....... | 57,000 | ............ | 106,800 | 18.33 | 39.73 |
| 10 | *2 | $C_5$ | ....do ....... | 2 | ....do ....... | 51,000 | ............ | 96,400 | 20.00 | 42.72 |

* Not accepted on these results; retempered and annealed.

† Not accepted on these results; reannealed.

*Results of tensile tests of tangential specimens from hoops for 8-inch and 10-inch B. L. rifles*—Continued.

| Caliber. | Number of hoop. | Mark of hoop. | Breech or muzzle. | Number of specimen. | Position of specimen. | Elastic limit per square inch of original section. | Elongation per inch under strain at elastic limit. | Tensile strength per square inch of original section. | Elongation after rupture. | Reduction of area after rupture. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Pounds.* | *Inch.* | *Pounds.* | *Per ct.* | *Per ct.* |
| 10 | *2 | $C_5$ | Breech | 1 | Middle | 59,000 | .......... | 106,000 | 19.33 | 38.90 |
| 10 | *2 | $C_5$ | ...do | 2 | ...do | 57,000 | .......... | 108,000 | 16.83 | 38.90 |
| 10 | 2 | $C_5$ | Muzzle | 3 | ...do | 59,000 | .002033 | 110,800 | 16.50 | 40.00 |
| 10 | 2 | $C_5$ | ...do | 4 | ...do | 59,000 | .002033 | 113,200 | 16.00 | 34.39 |
| 10 | 2 | $C_5$ | Breech | 3 | ...do | 57,000 | .001883 | 104,400 | 18.33 | 42.99 |
| 10 | 2 | $C_5$ | ...do | 4 | ...do | 59,000 | .002117 | 108,400 | 18.33 | 38.62 |
| 10 | 3 | $C_5$ | ...do | 1 | ...do | 57,000 | .002000 | 108,400 | 17.67 | 36.94 |
| 10 | 8 | $C_5$ | ...do | 2 | ...do | 59,000 | .002100 | 109,200 | 15.67 | 35.82 |
| 10 | 4 | $C_5$ | Muzzle | 1 | ...do | 61,000 | .002050 | 110,800 | 15.83 | 36.67 |
| 10 | 4 | $C_5$ | ...do | 2 | ...do | 54,000 | .001833 | 106,800 | 15.67 | 30.01 |
| 10 | 4 | $C_5$ | Breech | 1 | ...do | 60,000 | .002000 | 110,400 | 14.67 | 21.46 |
| 10 | 4 | $C_5$ | ...do | 2 | ...do | 56,000 | .001883 | 108,000 | 18.00 | 33.52 |
| 8 | *10 | $C_6$ | Muzzle | 1 | ...do | —50,000 | .......... | 94,400 | 20.67 | 39.18 |
| 8 | *10 | $C_6$ | ...do | 2 | ...do | —45,000 | .......... | 92,000 | 20.00 | 40.83 |
| 8 | *10 | $C_6$ | Breech | 1 | Outside | 58,000 | .......... | 103,600 | 19.33 | 44.85 |
| 8 | *10 | $C_6$ | ...do | 2 | Middle | 57,000 | .......... | 101,200 | 19.83 | 44.58 |
| 8 | 10 | $C_6$ | Muzzle | 3 | ...do | 58,000 | .002050 | 103,200 | 16.33 | 29.12 |
| 8 | 10 | $C_6$ | ...do | 4 | ...do | 60,000 | .002083 | 105,600 | 17.83 | 35.82 |
| 8 | 10 | $C_6$ | Breech | 3 | ...do | 58,000 | .001967 | 110,800 | 18.00 | 38.07 |
| 8 | 10 | $C_6$ | ...do | 4 | ...do | 60,000 | .002100 | 114,000 | 17.17 | 36.67 |
| 8 | 13 | $C_6$ | Muzzle | 1 | ...do | 54,000 | .001800 | 104,000 | 16.17 | 30.01 |
| 8 | 13 | $C_6$ | ...do | 2 | ...do | 54,000 | .001900 | 106,000 | 19.67 | 42.99 |
| 8 | 13 | $C_6$ | Breech | 1 | Outside | 60,000 | .002083 | 99,200 | 17.00 | 38.62 |
| 8 | 13 | $C_6$ | ...do | 2 | Middle | 55,000 | .001967 | 96,400 | 18.50 | 38.07 |
| 8 | †14 | $C_6$ | Muzzle | 1 | ...do | 58,000 | .......... | 110,400 | 16.00 | 40.55 |
| 8 | †14 | $C_6$ | ...do | 2 | ...do | 63,000 | .......... | 114,800 | 13.50 | 32.94 |
| 8 | †14 | $C_6$ | Breech | 1 | ...do | 62,000 | .......... | 114,400 | 15.33 | 35.82 |
| 8 | †14 | $C_6$ | ...do | 2 | ...do | 61,000 | .......... | 114,800 | 14.33 | 35.82 |
| 8 | 14 | $C_6$ | Muzzle | 3 | ...do | 56,000 | .001983 | 106,000 | 16.67 | 37.23 |
| 8 | 14 | $C_6$ | ...do | 4 | ...do | 58,000 | .001950 | 111,200 | 17.00 | 39.73 |
| 8 | 14 | $C_6$ | Breech | 3 | ...do | 58,000 | .001950 | 110,400 | 18.00 | 38.62 |
| 8 | 14 | $C_6$ | ...do | 4 | ...do | 58,000 | .001983 | 109,600 | 15.33 | 40.28 |
| 8 | 17 | $C_6$ | Muzzle | 1 | ...do | 56,000 | .002350 | 108,000 | 18.17 | 39.73 |
| 8 | 17 | $C_6$ | ...do | 2 | ...do | 58,000 | .002017 | 110,400 | 17.33 | 38.35 |
| 8 | 17 | $C_6$ | Breech | 1 | ...do | 56,000 | .002033 | 107,600 | 16.33 | 38.90 |
| 8 | 17 | $C_6$ | ...do | 2 | ...do | 55,000 | .001933 | 103,200 | 18.33 | 38.90 |
| 8 | 19 | $C_6$ | Muzzle | 1 | ...do | 52,000 | .001750 | 98,800 | 18.33 | 41.64 |
| 8 | 19 | $C_6$ | ...do | 2 | ...do | 54,000 | .001817 | 102,000 | 17.00 | 37.51 |
| 8 | 19 | $C_6$ | Breech | 1 | ...do | 54,000 | .001950 | 103,600 | 17.67 | 24.88 |
| 8 | 19 | $C_6$ | ...do | 2 | ...do | 56,000 | .001850 | 105,200 | 15.00 | 34.89 |
| 8 | 20 | $C_6$ | Muzzle | 1 | ...do | 56,000 | .002083 | 106,400 | 15.67 | 27.62 |
| 8 | 20 | $C_6$ | ...do | 2 | ...do | 52,000 | .001983 | 101,600 | 18.67 | 36.67 |
| 8 | 20 | $C_6$ | Breech | 1 | ...do | 56,000 | .002050 | 105,600 | 17.33 | 31.49 |
| 8 | 20 | $C_6$ | ...do | 2 | ...do | 56,000 | .002067 | 102,400 | 15.17 | 33.23 |
| 8 | 23 | $C_6$ | Muzzle | 1 | ...do | 56,000 | .001967 | 112,800 | 14.00 | 22.09 |
| 8 | 23 | $C_6$ | ...do | 2 | ...do | 56,000 | .002000 | 108,800 | 15.00 | 35.82 |
| 8 | 23 | $C_6$ | ...do | 3 | ...do | 60,000 | .002100 | 114,400 | 14.50 | 24.88 |
| 8 | 23 | $C_6$ | ...do | 4 | ...do | 58,000 | .002000 | 112,000 | 15.00 | 25.18 |
| 8 | 23 | $C_6$ | Breech | 1 | ...do | 60,000 | .002117 | 112,400 | 16.67 | 36.10 |
| 8 | 23 | $C_6$ | ...do | 2 | ...do | 59,000 | .002117 | 109,600 | 16.67 | 36.94 |
| 10 | †2 | $C_6$ | Muzzle | 1 | Outside | 63,000 | .......... | 112,400 | 15.00 | 36.67 |
| 10 | †2 | $C_6$ | ...do | 2 | Middle | 53,000 | .......... | 98,400 | 19.33 | 39.73 |
| 10 | †2 | $C_6$ | Breech | 1 | Outside | 62,000 | .......... | 109,600 | 10.67 | 11.28 |
| 10 | †2 | $C_6$ | ...do | 2 | Middle | 57,000 | .......... | 103,600 | 17.67 | 39.73 |
| 10 | *2 | $C_6$ | Muzzle | 3 | ...do | 52,000 | .......... | 98,400 | 19.67 | 42.45 |
| 10 | *2 | $C_6$ | ...do | 4 | ...do | 50,000 | .......... | 97,600 | 19.83 | 42.18 |
| 10 | *2 | $C_6$ | Breech | 3 | ...do | 51,000 | .......... | 97,200 | 21.83 | 44.32 |
| 10 | *2 | $C_6$ | ...do | 4 | ...do | 55,000 | .......... | 101,600 | 17.50 | 30.90 |
| 10 | 2 | $C_6$ | Muzzle | 5 | ...do | 56,000 | .001800 | 104,000 | 18.33 | 41.91 |
| 10 | 2 | $C_6$ | ...do | 6 | ...do | 57,000 | .001900 | 105,200 | 19.33 | 38.35 |
| 10 | 2 | $C_6$ | Breech | 5 | ...do | 57,000 | .001883 | 106,800 | 18.33 | 39.18 |
| 10 | 2 | $C_6$ | ...do | 6 | ...do | 57,000 | .001917 | 102,000 | 19.00 | 42.99 |
| 10 | *2 | $C^7$ | Muzzle | 1 | ...do | 54,000 | .......... | 98,800 | 18.67 | 41.37 |
| 10 | *2 | $C_7$ | ...do | 2 | ...do | 51,000 | .......... | 93,200 | 23.33 | 39.18 |
| 10 | *2 | $C_7$ | Breech | 1 | ...do | 57,000 | .......... | 98,000 | 19.83 | 45.37 |
| 10 | *2 | $C_7$ | ...do | 2 | ...do | 57,000 | .......... | 103,200 | 21.33 | 42.45 |

* Not accepted on these results; retempered and annealed.
† Not accepted on these results; reannealed.

*Results of tensile tests of tangential specimens from hoops for 8-inch and 10-inch B. L. rifles*—Continued.

| Caliber. | Number of hoop. | Mark of hoop. | Breech or muzzle. | Number of specimen. | Position of specimen. | Elastic limit per square inch of original section. | Elongation per inch. under strain at elastic limit. | Tensile strength per square inch of original section. | Elongation after rupture. | Reduction of area after rupture. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Pounds.* | *Inch.* | *Pounds* | *Per ct.* | *Per ct.* |
| 10 | 2 | $C_7$ | Muzzle | 3 | Middle | 55,000 | .001967 | 110,000 | 16.67 | 33.52 |
| 10 | 2 | $C_7$ | ....do | 4 | ....do | 55,000 | .001933 | 107,600 | 17.33 | 37.51 |
| 10 | 2 | $C_7$ | Breech | 3. | ....do | 56,000 | .002017 | 107,600 | 17.83 | 36.38 |
| 10 | 2 | $C_7$ | ....do | 4 | ....do | 53,000 | .001883 | 104,400 | 18.17 | 38.07 |
| 10 | 4 | $C_7$ | Muzzle | 1 | ....do | 57,000 | .001917 | 100,000 | 20.00 | 43.52 |
| 10 | 4 | $C_7$ | ....do | 2 | ....do | 55,000 | .001733 | 98,400 | 21.83 | 45.37 |
| 10 | 4 | $C_7$ | Breech | 1 | ....do | 54,000 | .001750 | 98,400 | 20.00 | 44.58 |
| 10 | 4 | $C_7$ | ....do | 2 | ....do | 57,000 | .001900 | 98,400 | 23.33 | 47.70 |
| 8 | *6 | Bu | | 1 | Outside | 64,000 | | 110,000 | 26.10 | 26.10 |
| 8 | *6 | Bu | | 2 | Middle | 59,000 | | 107,600 | 12.33 | 20.18 |
| 8 | 6 | Bu | | 3 | Outside | 54,000 | .001817 | 102,000 | 16.17 | 21.46 |
| 8 | 6 | Bu | | 4 | Middle | 54,000 | .001967 | 102,800 | 16.17 | 35.25 |
| 8 | *9 | Bu | | 1 | Outside | 60,000 | | 108,400 | 11.67 | 17.32 |
| 8 | *9 | Bu | | 2 | Middle | 58,000 | | 104,000 | 8.33 | 11.76 |
| 8 | 9 | Bu | | 3 | Outside | 57,000 | .001917 | 102,000 | 13.67 | 20.84 |
| 8 | 9 | Bu | | 4 | Middle | 56,000 | .002000 | 101,200 | 18.50 | 41.37 |
| 8 | *10 | Bu | | 1 | Outside | 59,000 | | 110,400 | 11.00 | 24.57 |
| 8 | *10 | Bu | | 2 | Middle | 72,000 | | 110,800 | 13.33 | 27.62 |
| 8 | *10 | Bu | | 3 | Outside | 58,000 | | 104,400 | 7.66 | 11.00 |
| 8 | *10 | Bu | | 4 | Middle | 56,000 | | 101,200 | 15.67 | 34.39 |
| 8 | 10 | Bu | | 5 | Outside | 59,000 | .002150 | 109,200 | 17.00 | 40.55 |
| 8 | 10 | Bu | | 6 | Middle | 56,000 | .002000 | 102,800 | 18.17 | 37.79 |
| 8 | *13 | Bu | | 1 | Outside | 58,000 | | 106,800 | 11.83 | 21.77 |
| 8 | *13 | Bu | | 2 | Middle | 58,000 | | 110,000 | 14.33 | 35.25 |
| 8 | 13 | Bu | | 3 | Outside | 58,000 | .002150 | 106,000 | 15.50 | 26.41 |
| 8 | 13 | Bu | | 4 | Middle | 56,000 | .002050 | 104,800 | 15.00 | 27.62 |
| 8 | *14 | Bu | | 3 | Outside | 56,000 | | 103,200 | 17.33 | 38.07 |
| 8 | *14 | Bu | | 4 | Middle | 52,000 | | 97,200 | 19.00 | 45.89 |
| 8 | 14 | Bu | | 5 | ....do | 55,000 | .002017 | 100,400 | 17.83 | 44.05 |
| 8 | 14 | Bu | | 6 | ....do | 56,000 | .001850 | 100,000 | 17.67 | 41.91 |
| 8 | *17 | Bu | | 1 | Outside | 58,000 | | 104,000 | 15.33 | 40.55 |
| 8 | *17 | Bu | | 2 | Middle | 51,000 | | 95,200 | 19.67 | 42.45 |
| 8 | 17 | Bu | | 3 | ....do | 55,000 | .001883 | 101,000 | 16.67 | 39.45 |
| 8 | 17 | Bu | | 4 | ....do | 57,000 | .002000 | 106,000 | 17.83 | 30.01 |
| 8 | 18 | Bu | | 1 | ....do | 59,000 | .001967 | 108,400 | 17.33 | 39.18 |
| 8 | 18 | Bu | | 2 | ....do | 59,000 | .001967 | 106,000 | 17.83 | 35.82 |
| 8 | *21 | Bu | | 1 | ....do | 61,000 | | 110,000 | 13.67 | 19.96 |
| 8 | *21 | Bu | | 2 | ....do | 57,000 | | 107,600 | 18.67 | 42.99 |
| 8 | 21 | Bu | | 3 | ....do | 55,000 | .001967 | 110,000 | 15.83 | 36.10 |
| 8 | 21 | Bu | | 4 | ....do | 56,000 | .002050 | 110,000 | 13.83 | 31.19 |
| 8 | 22 | Bu | | 1 | ....do | 55,000 | .001917 | 106,000 | 18.33 | 31.49 |
| 8 | 22 | Bu | | 2 | ....do | 55,000 | .001983 | 104,000 | 18.00 | 42.72 |
| 8 | 24 | Bu | | 1 | ....do | 55,000 | .001850 | 104,800 | 15.67 | 41.64 |
| 8 | 24 | Bu | | 2 | ....do | 54,000 | .001833 | 103,600 | 18.00 | 43.52 |

* **Not accepted on these results; retempered and annealed.**

*Results of tensile tests of tangential specimens from breech-mechanism forgings for 8-inch, 10-inch, and 12-inch B. L. rifles.*

**[Length of specimen, 3 inches; sectional area, 0.25 square inch.]**

| Caliber. | Number of gun. | Nature of piece tested. | Number of specimen. | Position of specimen. | Elastic limit per square inch of original section. | Elongation per inch under strain at elastic limit. | Tensile strength per square inch of original section. | Elongation after rupture. | Reduction in area after rupture. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Pounds.* | *Inch.* | *Pounds.* | *Per ct.* | *Per ct.* |
| 8 | *7 | Breechblock | 1 | Outside..... | 50,000 | ............ | 97,200 | 18.33 | 41.37 |
| 8 | *7 | ....do....... | 2 | Middle...... | —46,000 | ............ | 91,200 | 16.17 | 24.57 |
| 8 | *7 | ....do....... | 3 | Outside..... | —46,000 | ............ | 94,000 | 16.00 | 37.51 |
| 8 | *7 | ....do....... | 4 | Middle...... | 46,000 | ............ | 91,600 | 17.67 | 31.49 |
| 8 | 7 | ....do....... | 5 | Outside..... | 50,000 | .001667 | 97,200 | 18.33 | 43.25 |
| 8 | 7 | ....do....... | 6 | Middle...... | 44,000 | ............ | 90,400 | 17.33 | 37.23 |
| 8 | *9 | ....do....... | 1 | Outside..... | 46,000 | ............ | 87,600 | 20.00 | 41.10 |
| 8 | *9 | ....do....... | 2 | Middle...... | —46,000 | ............ | 85,600 | 21.33 | 39.45 |
| 8 | 9 | ....do....... | 3 | Outside..... | 49,000 | .001767 | 94,800 | 18.33 | 43.52 |
| 8 | 9 | ....do....... | 4 | Middle...... | 46,000 | .001417 | 92,400 | 18.83 | 40.83 |
| 8 | *11 | ....do....... | 1 | Outside..... | 54,000 | ............ | 104,000 | 16.67 | 36.94 |
| 8 | *11 | ....do....... | 2 | Middle...... | 52,600 | ............ | 101,200 | 13.67 | 24.26 |
| 8 | 11 | ....do....... | 3 | Outside..... | 52,000 | .001773 | 100,400 | 13.67 | 23.64 |
| 8 | 11 | ....do....... | 4 | Middle...... | 50,000 | .001733 | 99,200 | 16.83 | 36.38 |
| 8 | 12 | ....do....... | 1 | Outside..... | 51,000 | .001817 | 92,400 | 20.00 | 45.37 |
| 8 | 12 | ....do....... | 2 | Middle...... | 49,000 | .001733 | 90,400 | 22.00 | 42.99 |
| 8 | 14 | ....do....... | 1 | Outside..... | 51,000 | .001783 | 93,400 | 19.83 | 43.25 |
| 8 | 14 | ....do....... | 2 | Middle...... | 51,000 | .001783 | 90,800 | 19.17 | 33.81 |
| 8 | †16 | ....do....... | 1 | Outside..... | 58,000 | ............ | 102,400 | 10.00 | 12.00 |
| 8 | †16 | ....do....... | 2 | Middle...... | 53,000 | ............ | 101,200 | 9.33 | 11.32 |
| 8 | *16 | ....do....... | 3 | Outside..... | 55,000 | ............ | 95,200 | 17.67 | 44.58 |
| 8 | *16 | ....do....... | 4 | Middle...... | 48,000 | ............ | 95,600 | 12.67 | 24.26 |
| 8 | *16 | ....do....... | 5 | Outside..... | 59,000 | ............ | 102,400 | 12.33 | 44.58 |
| 8 | *16 | ....do....... | 6 | Middle...... | 54,000 | ............ | 99,200 | 15.33 | 31.49 |
| 8 | 16 | ....do....... | 7 | Outside..... | 54,000 | .001883 | 95,600 | 17.67 | 36.38 |
| 8 | 16 | ....do....... | 8 | Middle...... | 53,000 | .001850 | 95,600 | 15.83 | 17.56 |
| 8 | 19 | ....do....... | 1 | Outside..... | 50,000 | .001600 | 96,800 | 21.33 | 45.63 |
| 8 | 19 | ....do....... | 2 | Middle...... | 48,000 | .001633 | 95,200 | 16.67 | 16.60 |
| 8 | 21 | ....do....... | 1 | Outside..... | 52,000 | .001717 | 97,200 | 18.00 | 37.51 |
| 8 | 21 | ....do....... | 2 | Middle...... | 51,000 | .001717 | 92,800 | 17.00 | 28.82 |
| 8 | 22 | ....do....... | 1 | Outside..... | 50,000 | .001850 | 92,000 | 19.33 | 47.19 |
| 8 | 22 | ....do....... | 2 | Middle...... | 48,000 | .001500 | 88,800 | 19.33 | 45.89 |
| 8 | 24 | ....do....... | 1 | Outside..... | 49,000 | .001700 | 89,600 | 23.67 | 48.72 |
| 8 | 24 | ....do....... | 2 | Middle...... | 49,000 | .001717 | 92,000 | 16.33 | 26.10 |
| 10 | 2 | ....do....... | 1 | Outside..... | 50,000 | .001750 | 90,800 | 19.00 | 42.99 |
| 10 | 2 | ....do....... | 2 | Middle.,.... | 49,000 | .001733 | 95,200 | 15.83 | 21.77 |
| 12 | 2 | ....do....... | 1 | Outside..... | 52,000 | .001767 | 88,400 | 20.17 | 44.85 |
| 12 | 2 | ....do....... | 2 | Middle...... | 47,000 | .001650 | 86,800 | 16.33 | 23.60 |
| 8 | 4 | Spindle..... | 1 | Outside..... | 53,000 | .001817 | 90,000 | 20.67 | 32.94 |
| 8 | 4 | ....do....... | 2 | Middle...... | 53;000 | .001800 | 86,800 | 18.00 | 23.95 |
| 8 | 8 | ....do....... | 1 | Outside..... | 55,000 | .001917 | 90,000 | 20.50 | 35.82 |
| 8 | 8 | ....do....... | 2 | Middle...... | 51,000 | .001750 | 90,000 | 20.83 | 44.05 |
| 8 | 9 | ....do....... | 5 | Outside..... | 51,000 | .001850 | 95,200 | 17.83 | 44.85 |
| 8 | 9 | ....do....... | 6 | Middle...... | 47,000 | .001633 | 90,000 | 18.83 | 46.67 |
| 8 | 11 | ....do....... | 1 | Outside..... | 53,000 | .001883 | 98,800 | 19.00 | 34.68 |
| 8 | 11 | ....do....... | 2 | Middle...... | 49,000 | .001700 | 92,800 | 19.17 | 34.96 |
| 8 | 15 | ....do....... | 1 | Outside..... | 53,000 | .001867 | 100,000 | 17.00 | 39.18 |
| 8 | 15 | ....do....... | 2 | Middle...... | 50,000 | .001817 | 96,800 | 18.33 | 33.52 |
| 8 | 17 | ....do....... | 3 | Outside..... | 53,000 | .001833 | 94,400 | 18.33 | 45.11 |
| 8 | 17 | ....do....... | 4 | Middle...... | 53,000 | .001767 | 94,400 | 20.00 | 40.83 |
| 8 | 19 | ....do....... | 1 | Outside..... | 51,000 | .001817 | 99,200 | 16.50 | 28.52 |
| 8 | 19 | ....do....... | 2 | Middle...... | 46,000 | .001633 | 96,000 | 20.33 | 35.25 |
| 8 | 20 | ....do....... | 1 | Outside..... | 51,000 | .001917 | 102,400 | 16.17 | 34.96 |
| 8 | 20 | ....do....... | 2 | Middle...... | 49,000 | .001817 | 99,200 | 15.67 | 29.42 |
| 8 | *21 | ....do....... | 1 | Outside..... | 51,000 | ............ | 99,600 | 16.67 | 33.23. |
| 8 | *21 | ....do....... | 2 | Middle...... | 49,000 | ............ | 98,400 | 13.83 | 19.91 |
| 8 | 21 | ....do....... | 3 | Outside..... | 51,000 | .001750 | 95,200 | 18.83 | 42.18 |
| 8 | 21 | ....do....... | 4 | Middle...... | 49,000 | .001667 | 93,200 | 18.00 | 40.83 |
| 8 | 23 | ....do....... | 1 | Outside..... | 51.000 | .001750 | 92,800 | 18.67 | 36.67 |
| 8 | 23 | ....do....... | 2 | Middle...... | 50,000 | .001800 | 98.800 | 18.33 | 29.42 |
| 12 | 2 | ....do....... | 1 | Outside..... | 55,000 | .001983 | 93,600 | 19.00 | 44.05 |
| 12 | 2 | ....do....... | 2 | Middle...... | 50,000 | .001967 | 92,000 | 17.67 | 40.83 |
| 8 | *2 | Gas-check .. | 5 | Outside..... | 70.000 | ............ | 130,400 | 11.67 | 19.60 |
| 8 | *2 | Cups ...... | 6 | Middle...... | —60,000 | ............ | 118,000 | 13.00 | 25.49 |

* Not accepted on these results; retempered and annealed.
† Not accepted on these results; reannealed.

*Results of tensile tests of tangential specimens from breech-mechanism forgings for 8-inch, 10-inch, and 12-inch B. L. rifles*—Continued.

| Caliber. | Number of gun. | Nature of piece tested. | Number of specimen. | Position of specimen. | Elastic limit per square inch of original section. | Elongation per inch under strain at elastic limit. | Tensile strength per square inch of original section. | Elongation after rupture. | Reduction in area after rupture. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Pounds.* | *Inch.* | *Pounds.* | *Per ct.* | *Per ct.* |
| 8 | 2 | Cups ...... | 7 | Outside..... | 80,000 | .002783 | 145,200 | 11.17 | 29.42 |
| 8 | 2 | ....do ....... | 8 | Middle...... | 72,000 | .002467 | 138,000 | 10.00 | 25.49 |
| 8 | 5 | ....do ....... | 1 | Outside..... | 75,000 | .002617 | 140,800 | 11.00 | 33.81 |
| 8 | 5 | ....do ....... | 2 | Middle...... | 77,000 | .002783 | 146,000 | 10.00 | 27.92 |
| 8 | 9 | ....do ....... | 1 | Outside..... | 73,000 | .002533 | 121,600 | 15.67 | 45.63 |
| 8 | 9 | ....do ....... | 2 | Middle...... | 70,000 | ............ | 120,800 | 16.67 | 41.91 |
| 8 | 11 | ....do ....... | 1 | Outside..... | 95,000 | .003417 | 168,800 | 11.00 | 23.64 |
| 8 | 11 | ....do ....... | 2 | Middle...... | 94,000 | .003283 | 167,200 | 9.917 | 25.80 |
| 8 | *13 | ....do ....... | 1 | Outside..... | 71,000 | ............ | 142,000 | 11.83 | 22.40 |
| 8 | *13 | ....do ....... | 2 | Middle...... | −70,000 | ............ | 132,000 | 12.33 | 26.41 |
| 8 | *13 | ....do ....... | 3 | Outside..... | 75,000 | ............ | 134,400 | 12.00 | 36.94 |
| 8 | *13 | ....do ....... | 4 | Middle...... | −70,000 | ............ | 126,800 | 12.83 | 37.79 |
| 8 | *13 | ....do ....... | 5 | Outside..... | 70,000 | ............ | 123,200 | 15.33 | 40.28 |
| 8 | *13 | ....do ....... | 6 | Middle...... | −70,000 | ............ | 128,400 | 14.83 | 35.82 |
| 8 | 13 | ....do ....... | 7 | Outside..... | 83,000 | .002850 | 154,000 | 10.67 | 35.25 |
| 8 | 13 | ....do ....... | 8 | Middle...... | 77,000 | .002583 | 152,400 | 10.50 | 32.36 |
| 8 | 16 | ....do ....... | 1 | Outside..... | 94,000 | .003300 | 155,800 | 12.00 | 29.12 |
| 8 | 16 | ....do ....... | 2 | Middle...... | 95,000 | .003233 | 159,200 | 12.00 | 28.52 |
| 8 | 18 | ....do ....... | 1 | ....do ....... | 89,000 | .003233 | 157,600 | 10.83 | 26.10 |
| 8 | 18 | ....do ....... | 2 | Outside..... | 93,000 | .003383 | 159,200 | 10.00 | 25.18 |
| 8 | 20 | ....do ....... | 1 | ....do ....... | 101,000 | .003417 | 170,000 | 10.83 | 28.52 |
| 8 | 20 | ....do ....... | 2 | Middle...... | 99,000 | .003400 | 162,400 | 10.33 | 25.18 |
| 8 | 22 | ....do ....... | 1 | Outside..... | 95,000 | .003283 | 163,200 | 11.00 | 22.40 |
| 8 | 22 | ....do ....... | 2 | Middle...... | 89,000 | .003200 | 160,600 | 11.00 | 25.18 |
| 10 | 2 | ....do ....... | 1 | Outside..... | 77,000 | .002700 | 142,400 | 11.33 | 20.54 |
| 10 | 2 | ....do ....... | 2 | Middle...... | 82,000 | .002767 | 150,400 | 12.00 | 25.49 |
| 10 | 4 | ....do ....... | 1 | Outside..... | 95,000 | .003167 | 160,000 | 10.83 | 16.60 |
| 10 | 4 | ....do ....... | 2 | Middle...... | 90,000 | .003033 | 159,200 | 10.83 | 21.77 |
| 12 | 2 | Gas-check .. | 1 | Outside..... | 84,000 | .002900 | 150,400 | 12.33 | 29.71 |
| 12 | 2 | Cups ....... | 2 | Middle...... | 78,000 | .002800 | 150,800 | 11.83 | 26.10 |
| 12 | 4 | ....do ....... | 1 | Outside..... | 82,000 | .002767 | 154,400 | 10.83 | 25.80 |
| 12 | 4 | ....do ....... | 2 | Middle...... | 80,000 | .002683 | 156,000 | 9.67 | 22.40 |

* Not accepted on these results; retempered and annealed.

*Results of tensile tests of longitudinal specimens from breech-mechanism forgings for 8-inch, 10-inch, and 12-inch B. L. rifles.*

[Length of specimen, 3 inches; sectional area, 0.25 square inch.]

| Caliber. | Number of gun. | Nature of piece tested. | Number of specimen. | Position of specimen. | Elastic limit per square inch of original section. | Elongation per inch under strain at elastic limit. | Tensile strength per square inch of original section. | Elongation after rupture. | Contraction in area after rupture. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Pounds.* | *Inch.* | *Pounds.* | *Per ct.* | *Per ct.* |
| 8 | *12 | Hinge pin .. | 1 | Middle...... | −46,000 | ............ | 81,600 | 26.50 | 54.64 |
| 8 | 12 | ....do ....... | 2 | ....do ....... | 52,000 | .001883 | 93,200 | 21.00 | 55.36 |
| 8 | 15 | ....do ....... | 1 | ....do ....... | 52,000 | .001783 | 94,000 | 23.33 | 55.50 |
| 8 | 20 | ....do ....... | 1 | ....do ....... | 50,000 | .001550 | 94,800 | 21.33 | 53.68 |
| 8 | 22 | ....do ....... | 1 | ....do ....... | 49,000 | .001717 | 92,800 | 18.33 | 51.48 |
| 8 | 24 | ....do ....... | 1 | ....do ....... | 54,000 | .001817 | 94,000 | 19.83 | 54.16 |
| 10 | 2 | ....do ....... | 1 | ....do ....... | 51,000 | .001750 | 97,800 | 14.83 | 41.91 |
| 10 | 5 | ....do ....... | 1 | ....do ....... | 51,000 | .001900 | 97,600 | 17.17 | 42.99 |
| 10 | 8 | ....do ....... | 1 | ....do ....... | 59,000 | .002433 | 100,800 | 17.50 | 46.15 |
| 10 | 11 | ....do ....... | 1 | ....do ....... | 52,000 | .001750 | 99,600 | 16.00 | 41.10 |
| 10 | 14 | ....do ....... | 1 | ....do ....... | 50,000 | .001717 | 98,400 | 15.00 | 38.07 |
| 10 | 17 | ....do ....... | 1 | ....do ....... | 53,000 | .002033 | 99,200 | 18.00 | 44.58 |
| 10 | 20 | ....do ....... | 1 | ....do ....... | 63,000 | .002267 | 104,400 | 20.17 | 52.22 |
| 10 | 23 | ....do ....... | 1 | ....do ....... | 60,000 | .002183 | 101,600 | 20.00 | 51.73 |
| 12 | 7 | ....do ....... | 1 | ....do ....... | 56,000 | .002017 | 91,600 | 17.67 | 40.00 |
| 8 | 12 | Translating roller. | 1 | ....do ....... | 49,000 | .001567 | 95,600 | 20.00 | 50.73 |
| 8 | *13 | ....do ....... | 1 | ....do ....... | −40,000 | ............ | 78,400 | 27.50 | 57.22 |
| 8 | 13 | ....do ....... | 2 | ....do ....... | 52,000 | .001800 | 96,000 | 21.00 | 51.73 |
| 8 | 16 | ....do ....... | 1 | ....do ....... | 54,000 | .001867 | 96,000 | 21.67 | 53.68 |
| 8 | 21 | ....do ....... | 1 | ....do ....... | 55,000 | .001833 | 98,800 | 18.67 | 49.23 |
| 8 | 24 | ....do ....... | 1 | ....do ....... | 51,000 | .001833 | 96,000 | 20.00 | 50.24 |
| 10 | 4 | ....do ....... | 1 | ....do ....... | 49,000 | .001733 | 77,200 | 27.33 | 59.96 |
| 10 | 7 | ....do ....... | 1 | ....do ....... | 50,000 | .001667 | 78,000 | 25.67 | 60.85 |
| 10 | 10 | ....do ....... | 1 | ....do ....... | 51,000 | .001817 | 80,400 | 26.00 | 61.29 |
| 10 | 12 | ....do ....... | 1 | ....do ....... | 53,000 | .001800 | 80,000 | 26.00 | 61.63 |
| 10 | 16 | ....do ....... | 1 | ....do ....... | 52,000 | .001800 | 80,000 | 25.83 | 60.41 |
| 10 | 19 | ....do ....... | 1 | ....do ....... | 49,000 | .001633 | 80,000 | 26.33 | 59.51 |
| 10 | 22 | ....do ....... | 1 | ....do ....... | 52,000 | .001817 | 79,600 | 25.50 | 58.00 |
| 10 | 24 | ....do ....... | 1 | ....do ....... | 54,000 | .002000 | 83,600 | 24.33 | 59.28 |
| 12 | 4 | ....do ....... | 1 | ....do ....... | 54,000 | .001833 | 96,000 | 20.00 | 50.73 |
| 12 | 14 | ....do ....... | 1 | ....do ....... | 57,000 | .001983 | 96,000 | 20.67 | 52.48 |
| 10 | 8 | Securing pin. | 1 | ....do ....... | 98,000 | .003183 | 166,800 | 12.33 | 31.19 |
| 10 | 10 | ....do ....... | 1 | ....do ....... | 92,000 | .003050 | 160,400 | 12.67 | 32.94 |
| 12 | 8 | ....do ....... | 1 | ....do ....... | 89,000 | .003183 | 158,000 | 12.67 | 36.94 |

*Not accepted on these results; retempered and annealed.

### *Forgings for 3.2-inch B. L. rifle (Driggs-Schroeder breech mechanism).*

At the date of last report the tube and breechblock required under this contract had been delivered and their physical qualities were reported. The contractors had considerable difficulty in the manufacture of a jacket, four forgings having been made before a satisfactory one was produced; this difficulty delayed the completion of the contract until February 18, 1891.

The physical qualities of the accepted jacket were as follows:

*Results of tensile tests of tangential specimens from jacket for 3.2-inch B. L. rifle (Driggs-Schroeder breech mechanism).*

[Length of specimen, 2 inches; sectional area, 0.2 square inch.]

| Breech or muzzle. | Number of specimen. | Position of specimen. | Elastic limit per square inch of original section. | Elongation per inch under strain at elastic limit. | Tensile strength per square inch of original section. | Elongation after rupture. | Reduction in area after rupture. |
|---|---|---|---|---|---|---|---|
| | | | *Pounds.* | *Inch.* | *Pounds.* | *Per cent.* | *Per cent.* |
| Muzzle | *7 | Middle | 51,000 | ............ | 96,000 | 12.50 | 16.66 |
| Do | *8 | ....do | 50,000 | ............ | 96,000 | 18.75 | 25.45 |
| Breech | *7 | ....do | 48,000 | ............ | 92,500 | 15.00 | 24.08 |
| Do | *8 | ....do | 49,000 | ............ | 92,500 | 21.00 | 41.87 |
| Muzzle | 9 | ....do | 50,000 | .001700 | 89,000 | 26.50 | 47.44 |
| Do | 10 | ....do | 51,000 | .001825 | 93,000 | 16.00 | 15.93 |
| Do | 11 | ....do | 49,000 | .001675 | 88,500 | 21.25 | 26.81 |
| Do | 12 | ....do | 50,000 | .001725 | 94,000 | 20.50 | 27.16 |
| Breech | 9 | ....do | 46,000 | .001625 | 91,000 | 23.00 | 36.30 |
| Do | 10 | ....do | 46,000 | .001600 | 88,000 | 24.25 | 45.14 |

* Not accepted on these results; reannealed.

### *Forgings for 12-inch B. L. mortar (steel).*

The manufacture of these forgings was delayed at first and an extension of two months of the date for delivery was granted the contractors. Delivery was completed several weeks before the expiration of this extended time.

The following are the physical qualities of those forgings which were not delivered at date of last report:

***Results of tests of tangential specimens from hoop forgings for 12-inch B. L. mortar (steel).***

**[Length of specimen, 4 inches; sectional area, 0.25 square inch.]**

| Mark of hoop. | Breech or muzzle. | Number of specimen. | Position of specimen. | Elastic limit per square inch of original section. | Elongation per inch under strain at elastic limit. | Tensile strength per square inch of original section. | Elongation after rupture. | Reduction in area after rupture. |
|---|---|---|---|---|---|---|---|---|
| | | | | *Pounds.* | *Inch.* | *Pounds.* | *Per cent.* | *Per cent.* |
| TH | .................. | *1 | Outside....... | 56,000 | ............ | 108,400 | 15.50 | 34.10 |
| TH | .................. | *2 | Middle. ...... | 48,000 | ............ | 104,000 | 12.125 | 22.09 |
| TH | .................. | *3 | Inside ........ | 57,000 | ............ | 111,200 | 14.75 | •30.60 |
| TH | .................. | 4 | Outside....... | 61,000 | .0020625 | 109,200 | 16.25 | 40.83 |
| TH | .................. | 5 | Inside ........ | 58,000 | .0020375 | 107,200 | 15.625 | 38.07 |
| TH | .................. | 6 | Middle........ | 52,000 | .0018875 | 108,000 | 12.12 | 23.64 |
| A$_3$ | Muzzle ........ | 1 | Outside....... | 57,000 | .0020625 | 101,600 | 17.00 | 39.73 |
| A$_3$ | ....do .......... | 2 | Middle........ | 52,000 | .0021125 | 99,600 | 13.00 | 15.72 |
| A$_3$ | ....do .......... | 3 | Inside ........ | 57,000 | .0020500 | 106,800 | 13.625 | 42.18 |
| A$_3$ | Breech ........ | 1 | Outside ....... | 58,000 | .0020750 | 104,000 | 16.25 | 38.62 |
| A$_3$ | ....do .......... | 2 | Middle........ | 53,000 | .0019125 | 93,200 | 18.625 | 40.83 |
| A$_3$ | ....do .......... | 3 | Inside ........ | 54,000 | .0019375 | 94,000 | 13.00 | 27.92 |
| C$_1$ | Muzzle ........ | *1 | Outside ....... | 60,000 | ............ | 108,000 | 14.625 | 36.94 |
| C$_1$ | ....do .......... | *2 | Middle........ | 56,000 | ............ | 108,400 | 18.75 | 28.82 |
| C$_1$ | ....do .......... | *3 | Inside........ | 62,000 | ............ | 113,200 | 12.25 | 25.80 |
| C$_1$ | Breech ........ | *1 | Outside ....... | 56,000 | ............ | 106,400 | 14.50 | 36.10 |
| C$_1$ | ....do .......... | *2 | Middle........ | 54,000 | ............ | 104,800 | 6.875 | 7.36 |
| C$_1$ | ....do .......... | *3 | Inside........ | 62,000 | ............ | 108,800 | 11.50 | 30.90 |
| C$_1$ | Muzzle ........ | 4 | Outside. ...... | 56,000 | .0019500 | 110,400 | 18.875 | 33.52 |
| C$_1$ | ....do .......... | 5 | Inside........ | 62,000 | .0020875 | 114,800 | 11.50 | 31.19 |
| C$_1$ | ....do .......... | 6 | Middle........ | 56,000 | .0020875 | 110,800 | 14.00 | 34.96 |
| C$_1$ | Breech ........ | 4 | Outside ....... | 59,000 | .0020500 | 107,200 | 16.00 | 42.45 |
| C$_1$ | ....do .......... | 5 | Inside........ | 64,000 | .0022000 | 113,200 | 13.75 | 33.23 |
| C$_1$ | ....do .......... | 6 | Middle........ | 55,000 | .0019625 | 107,600 | 14.75 | 33.52 |
| C$_2$ | Muzzle ........ | 1 | ....do.......... | 58,000 | .0020250 | 108,000 | 14.75 | 39.18 |
| C$_2$ | ....do .......... | 2 | ....do.......... | 61,000 | .0021500 | 109,200 | 15.50 | 43.25 |
| C$_2$ | ....do .......... | 3 | ....do.......... | 60,000 | .0021750 | 107,600 | 16.125 | 46.15 |
| C$_2$ | Breech......... | 1 | Outside ....... | 58,000 | .0020750 | 103,600 | 16.50 | 43.25 |
| C$_2$ | ....do .......... | 2 | Middle........ | 56,000 | .0020000 | 103,600 | 15.875 | 37.23 |
| C$_2$ | ....do .......... | 3 | Inside ........ | 57,000 | .0020000 | 104,400 | 17.50 | 44.05 |
| D$_1$ | .................. | 1 | Outside ....... | 57,000 | .0019875 | 108,000 | 14.50 | 36.10 |
| D$_1$ | .................. | 2 | Inside ........ | 56,000 | .0019875 | 107,200 | 13.625 | 33.52 |
| D$_1$ | .................. | 3 | Middle........ | 53,000 | .0018500 | 105,600 | 14.375 | 27.62 |

*Not accepted on these results; retempered and reannealed.

*Results of tests of specimens from breech-mechanism forgings for 12-inch B. L. mortar (steel).*

| Nature of piece tested. | Size of specimen. |  | How taken. | Number of specimen. | Position of specimen. | Elastic limit per square inch of original section. | Elongation per inch under strain at elastic limit. | Tensile strength per square inch of original section. | Elongation after rupture. | Reduction in area after rupture. |
|---|---|---|---|---|---|---|---|---|---|---|
|  | Length of stem. | Diameter of stem. |  |  |  |  |  |  |  |  |
|  | *In.* | *Inch.* |  |  |  | *Pounds.* | *Inch.* | *Pounds.* | *Per ct.* | *Per ct.* |
| Bushing | 3 | 0.564 | Tangentially. | *1 | Outside. | 56,000 | .......... | 108,000 | 10.00 | 11.38 |
| Do | 3 | 0.565 | ....do | *2 | Middle. | 56,000 | .......... | 106,400 | 12.17 | 11.36 |
| Do | 3 | 0.562 | ....do | †3 | Outside. | 57,000 | .......... | 109,600 | 13.33 | 25.13 |
| Do | 3 | 0.564 | ....do | †4 | Middle. | 55,000 | .......... | 106,000 | 15.33 | 35.82 |
| Do | 3 | 0.564 | ....do | 5 | Outside. | 60,000 | .002150 | 107,200 | 16.00 | 37.51 |
| Do | 3 | 0.564 | ....do | 6 | Middle. | 55,000 | .001933 | 104,000 | 15.83 | 35.53 |
| Breechblock | 3 | 0.559 | ....do | *1 | Outside. | 55,000 | .......... | 103,200 | 15.67 | 28.16 |
| Do | 3 | 0.565 | ....do | *2 | Middle. | 52,000 | .......... | 101,200 | 12.17 | 17.64 |
| Do | 3 | 0.564 | ....do | 3 | Outside. | 55,000 | .002017 | 102,800 | 16.00 | 29.71 |
| Do | 3 | 0.564 | ....do | 4 | Middle. | 48,000 | .001750 | 98,000 | 16.67 | 28.82 |
| Spindle | 3 | 0.564 | ....do | †1 | Outside. | 56,000 | .......... | 106,000 | 17.33 | 29.42 |
| Do | 3 | 0.565 | ....do | †2 | Middle. | 55,000 | .......... | 107,200 | 12.50 | 26.10 |
| Do | 3 | 0.564 | ....do | 3 | Outside. | 57,000 | .002017 | 104,000 | 17.67 | 28.52 |
| Do | 3 | 0.564 | ....do | 4 | Middle. | 52,000 | .001967 | 101,600 | 16.00 | 37.23 |
| Gas-check | 3 | 0.563 | ....do | 1 | Outside. | 85,000 | .003033 | 148,000 | 10.67 | 23.95 |
| Cups | 3 | 0.565 | ....do | 2 | Middle. | 76,000 | .002700 | 144,000 | 10.67 | 28.52 |

*Not accepted on these results; retempered and reannealed.
†Not accepted on these results; reannealed.

### *Forged-steel armored-deck plates.*

These plates were 120 by 58½ inches, two being 3½ and two 4½ inches thick, and were intended for the ballistic test of experimental 12-inch mortar shells, as well as to determine the effectiveness of the 12-inch mortars themselves against the plates they may be expected to meet in service. The plates were made with great care from selected ingots and showed excellent physical qualities; they are probably much better than a majority of the plates actually used on the decks of war vessels. After bolt holes had been tapped in them they were shipped to the proving ground at Sandy Hook, N. J.

The physical qualities were as follows:

*Results of test of specimens from forged-steel armored-deck plates.*

[Length of specimen, 3 inches; sectional area 0.25 square inch.]

| Thickness of plate. | Number of plate. | Breech or muzzle. | How taken. | Number of specimen. | Position of specimen. | Elastic limit per square inch of original section. | Tensile strength per square inch of original section. | Elongation after rupture. | Reduction in area after rupture. |
|---|---|---|---|---|---|---|---|---|---|
| *In.* | | | | | | *Pounds.* | *Pounds.* | *Per ct.* | *Per ct.* |
| 4.5 | 1 | | Longitudinally | *1 | Middle | | 70,800 | 27.50 | 47.96 |
| 4.5 | 1 | | Tangentially | *2 | do | | 80,800 | 19.33 | 41.91 |
| 4.5 | 1 | Breech | Longitudinally | *3 | | 32,800 | 71,200 | 28.00 | 52.69 |
| 4.5 | 1 | do | do | *4 | | 34,800 | 69,200 | 26.00 | 60.00 |
| 4.5 | 1 | do | Tangentially | *5 | | 32,800 | 76,000 | 22.30 | 48.22 |
| 4.5 | 1 | do | Longitudinally | *6 | | 32,400 | 74,000 | 20.50 | 52.25 |
| 4.5 | 1 | Muzzle | do | 1 | Middle | 39,200 | 78,000 | 24.66 | 53.16 |
| 4.5 | 1 | Breech | do | 7 | do | 40,600 | 81,600 | 21.33 | 50.75 |
| 4.5 | 2 | Muzzle | do | †1 | | 53,600 | 98,400 | 15.66 | 33.24 |
| 4.5 | 2 | Breech | do | †1 | | 53,600 | 97,600 | 14.33 | 32.91 |
| 4.5 | 2 | Muzzle | do | 2 | | 48,800 | 88,400 | 21.16 | 46.30 |
| 4.5 | 2 | Breech | do | 2 | | 49,200 | 84,400 | 23.00 | 52.97 |
| 3.5 | 1 | Muzzle | do | 1 | | 43,200 | 82,400 | 21.66 | 49.96 |
| 3.5 | 1 | Breech | do | 1 | | 44,000 | 86,000 | 19.00 | 46.63 |
| 3.5 | 2 | Muzzle | do | 1 | Middle | 48,000 | 88,400 | 20.00 | 51.20 |
| 3.5 | 2 | Breech | do | 1 | do | 46,400 | 86,400 | 21.00 | 54.60 |

* Not accepted on these results; retempered and annealed.
† Not accepted on these results; reannealed.

### *Forgings for 5-inch B. L. siege rifles.*

A little work was done under this contract in September, 1890, but it was then dropped until December, 1890, since which time it has been moving on very slowly. Other work has been pushed ahead and this has suffered in consequence; retreatment has been frequent and some of the tube forgings have been retreated more frequently than the obtained results seemed to warrant. The per diem penalty stated in this contract for nondelivery within the contract time happens to be not large enough to demand any special endeavor by the contractors when their other engagements are considered. Excepting three tubes and one jacket, all the forgings of the ten sets have been delivered; the excepted forgings will probably be delivered within two months.

The physical qualities of the accepted forgings are as follows:

*Results of tensile tests of tangential specimens from ends of tubes and jackets for 5-inch B. L. rifles.*

[All middle specimens. Length of specimen, 3 inches; sectional area, 0.25 square inch.]

| Nature of piece tested. | Number of gun. | Muzzle or breech. | Number of specimen. | Elastic limit per square inch of original section. | Elongation per inch under strain at elastic limit. | Tensile strength per square inch of original section. | Elongation after rupture. | Contraction of area after rupture. | Specific gravity. | Hardness. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | *Pounds.* | *Inch.* | *Pounds.* | *Per ct.* | *Per ct.* | | |
| Tube ... | *5 | Muzzle ... | 1 | 45,000 | .000000 | 88,800 | 19.67 | 32.65 | ........ | ........ |
| Do... | *5 | ....do ..... | 2 | 47,000 | .......... | 88,800 | 16.00 | 24.88 | ........ | ........ |
| Do... | *5 | Breech.... | 1 | 45,000 | .......... | 90,000 | 14.50 | 20.22 | ........ | ........ |
| Do... | *5 | ....do ..... | 2 | 46,000 | .......... | 90,400 | 20.17 | 42.45 | ........ | ........ |
| Do... | †5 | Muzzle ... | 3 | 42,000 | .......... | 88,800 | 20.00 | 42.72 | ........ | ........ |
| Do... | †5 | ....do ..... | 4 | 40,000 | .......... | 85,200 | 20.33 | 34.39 | ........ | ........ |
| Do... | †5 | Breech.... | 3 | 40,000 | .......... | 84,400 | 22.83 | 38.62 | ........ | ........ |
| Do... | †5 | ....do ..... | 4 | .......... | .......... | 84,400 | 17.83 | 32.94 | ........ | ........ |
| Do... | ‡5 | Muzzle ... | 5 | 43,000 | .......... | 86,400 | 17.00 | 24.88 | ........ | ........ |
| Do... | ‡5 | ....do ..... | 6 | 45,000 | .......... | 89,600 | 19.33 | 42.18 | ........ | ........ |
| Do... | ‡5 | Breech.... | 5 | 43,000 | .......... | 88,400 | 21.00 | 36.38 | ........ | ........ |
| Do... | ‡5 | ....do ..... | 6 | 43,000 | .......... | 90,000 | 20.00 | 35.53 | ........ | ........ |
| Do... | †5 | Muzzle ... | 7 | 42,000 | .......... | 88,400 | 17.17 | 30.01 | ........ | ........ |
| Do... | †5 | ....do ..... | 8 | 42,000 | .......... | 88,000 | 19.33 | 29.42 | ........ | ........ |
| Do... | 5 | ....do ..... | 9 | 45,000 | .001633 | 85,600 | 22.00 | 46.15 | ........ | ........ |
| Do... | 5 | ....do ..... | 10 | 45,000 | .001533 | 86,400 | 22.67 | 43.52 | ........ | ........ |
| Do... | 5 | Breech.... | 7 | 46,000 | .001633 | 88,800 | 18.00 | 31.19 | ........ | ........ |
| Do... | 5 | ....do ..... | 8 | 47,000 | .001683 | 89,200 | 20.00 | 42.18 | ........ | ........ |
| Do... | 6 | Muzzle ... | 1 | 51,000 | .001750 | 90,400 | 19.67 | 33.52 | ........ | ........ |
| Do... | 6 | ....do ..... | 2 | 48,000 | .001683 | 88,400 | 20.00 | 39.18 | ........ | ........ |
| Do... | 6 | Breech.... | 1 | 48,000 | .001600 | 91,600 | 19.50 | 43.79 | ........ | ........ |
| Do... | 6 | ....do ..... | 2 | 49,000 | .001683 | 92,000 | 19.33 | 44.85 | ........ | ........ |
| Do... | 7 | Muzzle ... | 1 | 47,000 | .001633 | 90,000 | 21.00 | 43.79 | ........ | ........ |
| Do... | 7 | ....do ..... | 2 | 49,000 | .001900 | 91,120 | 18.70 | 30.60 | ........ | ........ |
| Do... | 7 | Breech§... | 1 | 50,000 | .001750 | 90,000 | 25.25 | 42.47 | ........ | ........ |
| Do... | 7 | ....do§ .... | 2 | 46,000 | .001825 | 87,500 | 26.50 | 43.08 | 7.8536 | 16.48 |
| Do... | 8 | Muzzle. .. | 1 | 47,000 | .001583 | 85,600 | 21.50 | 47.96 | ........ | ........ |
| Do... | 8 | ....do ..... | 2 | 47,000 | .001733 | 88,000 | 17.50 | 36.10 | ........ | ........ |
| Do... | 8 | Breech.... | 1 | 45,000 | .001567 | 85,200 | 20.83 | 47.96 | ........ | ........ |
| Do... | 8 | ....do ..... | 2 | 44,000 | .001533 | 88,400 | 21.67 | 44.32 | ........ | ........ |
| Do... | 9 | Muzzle ... | 1 | 45,000 | .001600 | 88,000 | 18.50 | 45.37 | ........ | ........ |
| Do... | 9 | ....do ..... | 2 | 46,000 | .001633 | 90,800 | 18.33 | 41.91 | ........ | ........ |
| Do... | 9 | Breech.... | 1 | 45,000 | .001583 | 88,800 | 18.83 | 38.35 | ........ | ........ |
| Do... | 9 | ....do ..... | 2 | 46,000 | .001683 | 90,400 | 20.67 | 46.15 | ........ | ........ |
| Do... | ‡11 | Muzzle ... | 1 | 44,000 | .001767 | 90,800 | 15.67 | 19.91 | ........ | ........ |
| Do... | ‡11 | ....do ..... | 2 | 44,000 | .001817 | 90,800 | 19.00 | 34.39 | ........ | ........ |
| Do... | 11 | ....do ..... | 3 | 43,000 | .001600 | 90,000 | 18.67 | 33.52 | ........ | ........ |
| Do... | 11 | ....do ..... | 4 | 42,000 | .001667 | 88,400 | 18.50 | 33.52 | ........ | ........ |
| Do... | 11 | Breech.... | 1 | 49,000 | .001850 | 92,000 | 19.17 | 40.28 | ........ | ........ |
| Do... | 11 | ....do ..... | 2 | 48,000 | .001700 | 92,800 | 20.00 | 48.52 | ........ | ........ |
| Jacket.. | †2 | Muzzle ... | 1 | 51,000 | .......... | 100,000 | 18.67 | 34.96 | ........ | ........ |
| Do... | †2 | ....do ..... | 2 | 52,000 | .......... | 100,000 | 16.00 | 29.12 | ........ | ........ |
| Do... | †2 | Breech.... | 1 | 47,000 | .......... | 98,800 | 18.50 | 40.00 | ........ | ........ |
| Do... | †2 | ....do ..... | 2 | 46,000 | .......... | 95,600 | 18.33 | 32.65 | ........ | ........ |
| Do... | 2 | Muzzle ... | 3 | 53,000 | .001733 | 99,200 | 17.67 | 32.36 | ........ | ........ |
| Do... | 2 | ....do ..... | 4 | 52,000 | .001767 | 100,400 | 18.00 | 37.51 | ........ | ........ |
| Do... | 2 | Breech.... | 3 | 53,000 | .001817 | 99,200 | 18.67 | 44.32 | ........ | ........ |
| Do... | 2 | ....do ..... | 4 | 48,000 | .001717 | 97,600 | 20.00 | 43.79 | ........ | ........ |
| Do... | ‡3 | Muzzle ... | 1 | 54,000 | .002017 | 95,600 | 19.83 | 45.63 | ........ | ........ |
| Do... | ‡3 | ....do ..... | 2 | 53,000 | .001833 | 98,400 | 15.00 | 27.62 | ........ | ........ |
| Do... | 3 | ....do ..... | 3 | 50,000 | .001800 | 91,560 | 22.00 | 41.90 | ........ | ........ |
| Do... | 3 | ....do ..... | 4 | 51,000 | .001817 | 94,000 | 19.67 | 41.37 | ........ | ........ |
| Do... | 3 | Breech ... | 1 | 58,000 | .001817 | 95,600 | 19.67 | 41.91 | ........ | ........ |
| Do... | 3 | ....do ..... | 2 | 51,000 | .001783 | 92,000 | 21.00 | 40.55 | ........ | ........ |
| Do... | 4 | Muzzle ... | 1 | 53,000 | .001933 | 100,400 | 15.33 | 34.39 | ........ | ........ |
| Do... | 4 | ....do ..... | 2 | 49,000 | .001850 | 92,000 | 21.67 | 41.37 | ........ | ........ |
| Do... | 4 | ....do ..... | 3 | 51,000 | .001767 | 96,000 | 19.00 | 41.91 | ........ | ........ |
| Do... | 4 | Breech.... | 1 | 50,000 | .001833 | 96,800 | 17.67 | 35.53 | ........ | ........ |

* Not accepted on these results; reannealed.

† Not accepted on these results; retempered and annealed.

‡ Not accepted on these results; resubmitted.

§ Length of specimen, 2 inches; sectional area, 0.20 square inch.

*Results of tensile tests of tangential specimens from ends of tubes and jackets for 5-inch B. L. rifles*—Continued.

| Nature of piece tested. | Number of gun. | Muzzle or breech. | Number of specimen. | Elastic limit per square inch of original section. | Elongation per inch under strain at elastic limit. | Tensile strength per square inch of original section. | Elongation after rupture. | Contraction of area after rupture. | Specific gravity. | Hardness. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | *Pounds.* | *Inch.* | *Pounds.* | *Per ct.* | *Per ct.* | | |
| Jacket.. | 4 | Breech.... | 2 | 49,000 | .001783 | 90,800 | 20.67 | 42.45 | ........ | ........ |
| Do... | 4 | ....do ..... | 3 | 59,000 | .002150 | 101,200 | 18.67 | 45.37 | 7.8582 | 18.98 |
| Do... | 5 | Muzzle ... | 1 | 47,000 | .001600 | 94,400 | 18.67 | 43.79 | ........ | ........ |
| Do... | 5 | ....do ..... | 2 | 49,000 | .001767 | 94,000 | 19.67 | 41.64 | ........ | ........ |
| Do... | 5 | Breech.... | 1 | 48,000 | .001750 | 92,400 | 19.00 | 31.49 | ........ | ........ |
| Do... | 5 | ....do ..... | 2 | 50,000 | .001783 | 94,800 | 19.33 | 37.23 | ........ | ........ |
| Do... | 6 | Muzzle ... | 1 | 50,000 | .001783 | 93,200 | 21.67 | 44.58 | ........ | ........ |
| Do... | 6 | ....do ..... | 2 | 49,000 | .001717 | 93,200 | 19.67 | 44.58 | ........ | ........ |
| Do... | 6 | Breech.... | 1 | 52,000 | .001817 | 92,000 | 20.00 | 48.72 | ........ | ........ |
| Do... | 6 | ....do ..... | 2 | 50,000 | .001717 | 91,600 | 23.00 | 46.67 | ........ | ........ |
| Do... | *8 | Muzzle ... | 1 | 49,000 | .......... | 92,800 | 18.00 | 28.22 | ........ | ........ |
| Do... | *8 | ....do ..... | 2 | —46,000 | .......... | 90,000 | 18.00 | 45.63 | ........ | ........ |
| Do... | *8 | Breech.... | 1 | —46,000 | .......... | 84,000 | 21.17 | 46.41 | ........ | ........ |
| Do... | *8 | ....do ..... | 2 | 46,000 | .......... | 82,400 | 20.90 | 40.00 | ........ | ........ |
| Do... | 8 | Muzzle ... | 3 | 48,000 | .001650 | 98,000 | 14.83 | 41.91 | ........ | ........ |
| Do... | 8 | ....do ..... | 4 | 52,000 | .001783 | 92,800 | 17.17 | 46.41 | ........ | ........ |
| Do... | 8 | Breech.... | 3 | 48,000 | .001683 | 96,000 | 16.67 | 38.62 | ........ | ........ |
| Do... | 8 | ....do ..... | 4 | 50,000 | .001750 | 95,200 | 15.33 | 41.10 | ........ | ........ |
| Do... | 9 | Muzzle ... | 1 | 50,000 | .001883 | 98,800 | 16.50 | 34.68 | ........ | ........ |
| Do... | 9 | ....do ..... | 2 | 52,000 | .002117 | 98,800 | 18.33 | 43.25 | ........ | ........ |
| Do... | 9 | Breech.... | 1 | 52,000 | .002383 | 99,600 | 16.17 | 36.67 | ........ | ........ |
| Do... | 9 | ....do ..... | 2 | 50,000 | .001850 | 97,200 | 18.00 | 41.10 | ........ | ........ |
| Do... | *10 | Muzzle ... | 1 | 47,000 | .......... | 91,600 | 12.67 | 13.64 | ........ | ........ |
| Do... | *10 | ....do ..... | 2 | 46,000 | .......... | 94,000 | 15.67 | 20.82 | ........ | ........ |
| Do... | *10 | Breech.... | 1 | 47,000 | .......... | 90,000 | 19.67 | 43.79 | ........ | ........ |
| Do... | *10 | ....do ..... | 2 | 48,000 | .......... | 93,200 | 20.00 | 46.67 | ........ | ........ |
| Do... | 10 | Muzzle ... | 3 | 53,000 | .001983 | 98,400 | 17.33 | 34.10 | ........ | ........ |
| Do... | 10 | ....do ..... | 4 | 48,000 | .001600 | 93,200 | 21.17 | 44.32 | ........ | ........ |
| Do... | 10 | Breech.... | 3 | 47,000 | .001600 | 95,360 | 20.00 | 39.20 | ........ | ........ |
| Do... | 10 | ....do ..... | 4 | 53,000 | .001867 | 97,600 | 19.67 | 45.11 | 7.8542 | 18.58 |
| Do... | 11 | Muzzle ... | 1 | 55,000 | .001933 | 96,000 | 19.83 | 38.62 | ........ | ........ |
| Do... | 11 | ....do ..... | 2 | 53,000 | .001833 | 100,000 | 18.67 | 43.52 | ........ | ........ |
| Do... | 11 | Breech.... | 1 | 55,000 | .001900 | 96,400 | 21.50 | 47.19 | ........ | ........ |
| Do... | 11 | ....do ..... | 2 | 49,000 | .001683 | 90,400 | 22.17 | 46.67 | ........ | ........ |

* Not accepted on these results; retempered and annealed.

*Results of test of specimens from hoops and breech-mechanism forgings for 5-inch B. L. siege rifles.*

[All middle specimens.]

| Nature of piece tested. | Number of gun. | Length of stem. | Diameter of stem. | How taken. | Number of specimen. | Elastic limit per square inch of original section. | Elongation per inch under strain at elastic limit. | Tensile strength per square inch of original section. | Elongation after rupture. | Contraction in area after rupture. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | *In.* | *Inch.* | | | *Pounds.* | *Inch.* | *Pounds.* | *Per ct.* | *Per ct.* |
| Trunnion hoop. | 2 | 3 | 0.564 | Tangentially | 1 | 66,000 | .002250 | 112,000 | 15.33 | 37.79 |
| Do........ | 2 | 3 | 0.564 | ....do ........ | 2 | 61,000 | .002150 | 110,000 | 14.67 | 38.90 |
| Do........ | 2 | 3 | 0.564 | ....do ........ | 3 | 63,000 | .002083 | 111,600 | 17.00 | 39.18 |
| Do........ | 2 | 2 | 0.505 | Longitudinally | 4 | 56,000 | .002050 | 107,000 | 18.00 | 52.57 |
| Do........ | 3 | 3 | 0.564 | Tangentially.. | 1 | 57,000 | .002050 | 106,000 | 17.00 | 40.00 |
| Do........ | 3 | 3 | 0.564 | ....do ........ | 2 | 57,000 | .002233 | 105,200 | 17.50 | 41.91 |
| Do........ | 3 | 3 | 0.565 | ....do ........ | 3 | 60,000 | .002050 | 109,200 | 18.00 | 40.83 |
| Do........ | 4 | 3 | 0.564 | ....do ........ | 1 | 60,000 | .002150 | 109,200 | 17.33 | 39.18 |
| Do........ | 4 | 3 | 0.565 | ... do ........ | 2 | 63,000 | .002183 | 108,000 | 17.50 | 45.37 |
| Do........ | 4 | 3 | 0.564 | ....do ........ | 3 | 62,000 | .002000 | 108,400 | 17.83 | 41.91 |
| Do........ | 4 | 2 | 0.503 | Longitudinally | 4 | 57,000 | .002300 | 107,500 | 19.50 | 40.05 |
| Do........ | 5 | 3 | 0.564 | Tangentially.. | 1 | 58,000 | .002067 | 105,600 | 17.33 | 34.96 |
| Do........ | 5 | 3 | 0.564 | ....do ........ | 2 | 56,000 | .001967 | 106,800 | 19 00 | 41.10 |
| Do........ | 5 | 3 | 0.564 | ....do ........ | 3 | 57,000 | .002017 | 107,200 | 17.33 | 41.10 |
| Do........ | 6 | 3 | 0.564 | ....do ........ | 1 | 59,000 | 002050 | 108,400 | 15.83 | 35.82 |
| Do........ | 6 | 3 | 0.563 | ....do ........ | 2 | 57,000 | .001950 | 103,200 | 16.67 | 39.18 |
| Do........ | 6 | 3 | 0.564 | ....do ........ | 3 | 57,000 | .001933 | 105,600 | 17.67 | 41.37 |
| Do........ | 7 | 3 | 0 564 | ....do ........ | 1 | 58,000 | .001983 | 108,000 | 19 33 | 43.79 |
| Do........ | 7 | 3 | 0.564 | ....do ........ | 2 | 60,000 | .002083 | 108,400 | 18.83 | 43.25 |
| Do........ | 7 | 3 | 0.565 | ....do ........ | 3 | 60,000 | .001983 | 108,800 | 15.83 | 35.25 |
| Do........ | 7 | 3 | 0.564 | Longitudinally | 4 | 53,000 | .001900 | 107,200 | 14.67 | 29.42 |
| Do........ | 11 | 3 | 0.564 | Tangentially.. | 1 | 60,000 | .002133 | 111,200 | 17.67 | 36.94 |
| Do........ | 11 | 3 | 0.565 | ....do ........ | 2 | 56,000 | .002033 | 107,200 | 17 00 | 39 73 |
| Do........ | 11 | 3 | 0.564 | ....do ........ | 3 | 57,000 | .002000 | 106,800 | 18.33 | 42.72 |
| Sleeve ........ | 2 | 2 | 0.505 | ....do ........ | 1 | 61,000 | .002000 | 111,000 | 18 00 | 40.66 |
| Do........ | 2 | 3 | 0.565 | ....do ........ | 2 | 62,000 | .002200 | 116,000 | 15.00 | 32.36 |
| Do........ | 5 | 2 | 0.504 | ....do ........ | 1 | 61,000 | .001800 | 112,000 | 17.50 | 38.81 |
| Do........ | 5 | 3 | 0.562 | ....do ........ | 2 | 62,000 | .002217 | 110,800 | 16.83 | 41.37 |
| Do........ | 7 | 3 | 0.555 | ....do ........ | 1 | 57,000 | .001900 | 108,700 | 16.50 | 42.45 |
| Do........ | 7 | 3 | 0.563 | ....do ........ | 2 | 59,000 | .002017 | 106,000 | 19.83 | 45.63 |
| Do........ | 9 | 3 | 0.564 | ....do ........ | 1 | 67,000 | .002517 | 122,000 | 15.67 | 32.36 |
| Do........ | 9 | 3 | 0.564 | ....do ........ | 2 | 64,000 | .002100 | 116,400 | 17.00 | 35.53 |
| Do........ | 11 | 2 | 0.505 | ....do ........ | 1 | 57,000 | .001850 | 104,500 | 23.00 | 39.12 |
| Base ring..... | 2 | 2 | 0.503 | ....do ........ | 1 | 62,000 | .002075 | 110,000 | 20.75 | 40.05 |
| Do........ | 5 | 2 | 0.502 | ....do ........ | 1 | 63,000 | .002050 | 114,000 | 18.75 | 35.99 |
| Do........ | *6 | 2 | 0.503 | ....do ........ | 1 | 64,000 | .......... | 116,000 | 17.75 | 34.40 |
| Do........ | 6 | 2 | 0.505 | ....do ........ | 2 | 61,000 | .002025 | 112,000 | 19.75 | 40.66 |
| Do........ | *8 | 2 | 0.505 | ....do ........ | 1 | 68,000 | .......... | 118,000 | 15.50 | 27.16 |
| Do........ | 8 | 2 | 0.504 | ....do ........ | 2 | 62,000 | .002125 | 111,000 | 18.75 | 40.66 |
| Do........ | *11 | 2 | 0.505 | ....do ........ | 1 | 60,000 | .......... | 111,500 | 18.25 | 30.83 |
| Do........ | 11 | 2 | 0.502 | ....do ........ | 2 | 57,000 | .001800 | 111,000 | 19.00 | 35.35 |
| Key ring ..... | 2 | 2 | 0.506 | ....do ........ | 1 | 61,000 | .001950 | 112,000 | 19.75 | 42.47 |
| Do........ | 4 | 2 | 0.505 | ....do ........ | 1 | 63,000 | .002225 | 113,500 | 22.50 | 42.47 |
| Do........ | 8 | 2 | 0.505 | ....do ........ | 1 | 67,000 | .002175 | 117,500 | 16.75 | 37.57 |
| Do........ | 11 | 2 | 0.505 | ....do ........ | 1 | 61,000 | .002025 | 110,000 | 19.75 | 43.38 |
| Breechblock .. | *2 | 2 | 0.505 | ....do ........ | 1 | 54,000 | .......... | 98,000 | 16.00 | 25.79 |
| Do........ | 2 | 2 | 0.502 | ....do ........ | 2 | 46,000 | .001083 | 87,500 | 24.25 | 43.38 |
| Do........ | *8 | 2 | 0.505 | ....do ........ | 1 | 54,000 | .......... | 96,500 | 15.50 | 17.02 |
| Do........ | 8 | 2 | 0.505 | ....do ........ | 2 | 52,000 | .001800 | 92,500 | 21.25 | 41.87 |
| Do........ | *10 | 2 | 0.505 | ....do ........ | 1 | 57,000 | .......... | 100,000 | 7.50 | 8.51 |
| Do........ | 10 | 2 | 0.504 | ....do ........ | 2 | 54,000 | .001775 | 95,000 | 20.00 | 29.16 |
| Do........ | 11 | 2 | 0.505 | ....do ........ | 1 | 51,000 | .001650 | 91,500 | 23.00 | 36.94 |
| Spindle ....... | 3 | 2 | 0.503 | Longitudinally | 1 | 70,000 | .002250 | 112,000 | 20.00 | 48.87 |
| Do........ | *6 | 2 | 0.505 | ....do ........ | 1 | 54,000 | .......... | 104,000 | 14.50 | 33.43 |
| Do........ | 6 | 2 | 0.505 | ....do ........ | 2 | 60,000 | .002050 | 106,000 | 18.25 | 43.08 |
| Do........ | 8 | 2 | 0.505 | ....do ........ | 1 | 63,000 | .002050 | 105,000 | 19.25 | 48.58 |
| Do........ | 10 | 2 | 0.505 | ...do ........ | 1 | 67,000 | .002600 | 109,500 | 21.50 | 52.50 |
| Gas-check cups | 2 | 2 | 0.505 | Tangentially . | 1 | 101,000 | .003125 | 165,000 | 13.00 | 24.76 |
| Do........ | 5 | 2 | 0.504 | ....do ........ | 1 | 97,000 | .003350 | 161,000 | 14.75 | 31.80 |
| Do........ | †8 | 2 | 0.503 | ....do ........ | 1 | 60,000 | .......... | 123,250 | 15.25 | 33.56 |
| Do........ | 8 | 2 | 0.503 | ....do ........ | 2 | 89,000 | .003165 | 162,500 | 12.00 | 28.83 |
| Block carrier . | 2 | 2 | 0.504 | ....do ........ | 1 | 52,000 | .001850 | 91,000 | 21.25 | 41.27 |
| Do........ | 6 | 2 | 0.505 | ....do ........ | 1 | 52,000 | .001775 | 93,000 | 21.50 | 43.67 |

*Not accepted on these results; reannealed.
† Not accepted on these results; retempered and annealed.

### *Experimental steel shell for 12-inch B. L. mortar.*

Two lots (two each) of these shell have been manufactured, one of medium and one of hard steel, tempered and annealed. The selection of the metal and the mode of treatment of these lots have been purely a matter of judgment, as no data existed as a guide. The results of the ballistic test should give information leading to a close approximation to the desired shell in the next lots manufactured. The shell are awaiting test.

The qualities of the metal at the base are as follows:

*Results of test of tangential specimens from base of steel shell for 12-inch B. L. mortar.*

[Length of specimen, 2 inches; sectional area, 0.2 square inch.]

| Number of shell. | Number of specimen. | Position of specimen. | Elastic limit per square inch of original section. | Tensile strength per square inch of original section. | Elongation after rupture. | Reduction in area after rupture. |
|---|---|---|---|---|---|---|
| | | | *Pounds.* | *Pounds.* | *Per cent.* | *Per cent.* |
| 1 | 1 | Outside | 87,500 | 142,500 | 11.25 | 18.09 |
| 1 | 2 | Middle | 77,000 | 138,000 | 10.50 | 15.77 |
| 2 | *3 | ....do | 90,000 | 137,000 | 1.83 | 4.04 |
| 2 | *4 | ....do | 80,000 | 110,000 | 1.00 | 1.67 |
| 2 | 5 | ....do | 84,800 | 144,000 | 6.50 | 7.86 |
| 2 | 6 | ....do | 86,000 | 137,000 | 8.75 | 6.27 |
| 3 | 1 | Outside | 67,000 | 109,000 | 10.75 | 11.93 |
| 3 | 2 | Middle | 65,000 | 112,000 | 12.00 | 12.26 |
| 4 | 1 | Outside | 65,500 | 107,000 | 13.50 | 21.98 |
| 4 | 2 | Middle | 60,000 | 101,500 | 18.50 | 40.55 |

* Retempered and annealed.

### *Bolts and nuts for erection of armored-deck plates.*

The several orders for these bolts and nuts required that they should be steel forgings made from metal selected by the inspector, which would show a tensile strength of about 70,000 pounds per square inch after annealing. They were all well and carefully made and finished.

### *Rollers for 12-inch B. L. mortar carriage.*

These rollers were to replace some broken cast-iron rollers in the experimental Easton & Anderson mortar carriage at Sandy Hook, N. J. The requirements of manufacture were that the rollers should be forged, annealed, and completely finished, the metal to be such as would show a tensile strength of about 93,000 pounds per square inch after annealing, and the dimensions to vary only within very narrow limits, the bore having a close-running fit on an axle sent from Sandy Hook.

As completion of the test of the carriage was awaiting the replacement of the broken rollers the earliest delivery was desired; hence the time within which delivery could be made, using all the facilities of a large machine shop, was calculated, and delivery was required within that time under heavy penalty for delay and corresponding premium for earlier delivery.

The order was given December 4, 1890, and was completed December 24, 1890, exactly the calculated time. The rollers were shipped the day they were completed. The workmanship was very accurate and satisfactory.

### *Disk for chamber gauge, and securing pins and screws for 8-inch and 10-inch B. L. rifles.*

Both these orders were for small quantities of material needed promptly by the Department for manufacture or repairs. The work was taken in hand at once on receipt of order by the contractors and was completed without delay, the time consumed being but 10 or 15 days, which is about as soon as small pieces can be forged, treated, machined, and delivered.

### *Forgings for 3.2-inch B. L. rifle (Gerdon breech mechanism).*

These forgings were such as are required for a field gun, the jacket combining the jacket, trunnion-hoop, and base-ring forgings of the old model. The breech end of the jacket is fashioned to meet the requirements of the Gerdon breech mechanism. The manufacture proceeded without incident. The physical qualities of the forgings were as follows:

*Results of tests of tangential specimens from forgings for 3.2-inch B. L. rifle (Gerdon breech mechanism).*

[Length of specimen, 2 inches; sectional area, 0.2 square inch. All middle specimens.]

| Nature of piece tested. | Breech or muzzle. | Number of specimen. | Elastic limit per square inch of original section. | Elongation per inch under strain at elastic limit. | Tensile strength per square inch of original section. | Elongation after rupture. | Reduction in area after rupture. |
|---|---|---|---|---|---|---|---|
| | | | *Pounds.* | *Inch.* | *Pounds.* | *Per cent.* | *Per cent.* |
| Tube | Muzzle | 1 | 47,000 | .001650 | 87,000 | 23.00 | 46.60 |
| Do | ....do | 2 | 48,000 | .001575 | 85,000 | 20.50 | 36.62 |
| Do | Breech | 1 | 43,000 | .001450 | 86,500 | 22.25 | 44.55 |
| Do | ....do | 2 | 45,000 | .001575 | 86,000 | 22.50 | 43.38 |
| Jacket | Muzzle | *1 | 49,000 | .001717 | 97,200 | 17.17 | 40.55 |
| Do | ....do | *2 | 51,000 | .001800 | 100,400 | 18.30 | 36.40 |
| Do | Breech | 1 | 50,000 | .001600 | 99,200 | 19.00 | 34.40 |
| Do | ....do | 2 | 54,000 | .001775 | 101,500 | 17.75 | 29.44 |
| Breechblock | | 1 | 50,000 | .001575 | 92,000 | 19.00 | 31.80 |
| Gas-check cup | | 1 | 93,000 | .002775 | 167,000 | 11.50 | 21.29 |
| Spindle | | †1 | 59,000 | .002300 | 97,000 | 25.00 | 59.59 |

*Specimen taken longitudinally.

†3-inch specimens.

### *Plates for the ballistic test of armor-piercing shot.*

These plates are 9 inches and 11¼ inches thick and are intended for the ballistic test of 8-inch and 10-inch shot; they are required to be of uniform manufacture, and after all have been finally treated one is to be selected by the inspector to represent the lot. The one so selected is to be submitted to a ballistic test.

The plates should have been ready for the ballistic test on July 23, 1891, but at that date only two of the four had been forged. A penalty of $5 per day took effect that day and will continue until the presentation for selection. At this date all the plates have been forged and are being treated.

The bolts, nuts, and washers have not yet been manufactured.

### *Side plates.*

These plates are to be used in the erection of the plates for ballistic test of shot and are a part of the target structure. No requirement as to qualities is specified in the order; they are to be simply steel forgings of specific dimensions and to have holes drilled for the bolts connecting them with the target structure.

### *Securing pins and locking rings for 8-inch, 10-inch, and 12-inch B. L. rifles.*

The securing pins under the order were required to have the physical qualities stated for such forgings in the specifications governing the manufacture of steel forgings for cannon. The locking rings were annealed forgings from metal selected by the inspector, which should show in the forgings a tensile strength of about 75,000 pounds per square inch. The results of the test of specimens from the securing-pin forgings were as follows:

*Results of tests of longitudinal specimens from securing pin forgings for 8-inch, 10-inch, and 12-inch B. L. rifles.*

[Length of specimen, 2 inches; sectional area, 0.2 square inch.]

| Caliber of gun. | Number of specimen. | Elastic limit per square inch of original section. | Elongation per inch under strain at elastic limit. | Tensile strength per square inch of original section. | Elongation after rupture. | Reduction in area after rupture. |
|---|---|---|---|---|---|---|
| *In.* | | *Pounds.* | *Inch.* | *Pounds.* | *Per cent.* | *Per cent.* |
| 8 | 1 | 96,000 | .002950 | 156,000 | 16.00 | 40.36 |
| 8 | 2 | 94,000 | .003100 | 156,000 | 14.50 | 36.94 |
| 10 | *1 | 89,000 | .003217 | 149,600 | 14.33 | 41.64 |
| 10 | 2 | 96,000 | .003350 | 159,000 | 14.75 | 37.26 |
| 12 | *1 | 88,000 | .003100 | 150,800 | 13.83 | 45.63 |

*Length of specimen, 3 inches.

### *Forged-steel armored-deck plates.*

These plates were 120 by 58¼ inches and 3 inches thick, and are to be used for the same purpose as the plates 3½ and 4½ inches thick previously referred to in this report. They were made in the same manner and showed the following physical qualities:

*Results of tests of specimens from forged-steel armored-deck plates, 3 inches thick.*

[Length of specimen, 3 inches; sectional area, 0.25 square inch.]

| Number of plate. | Breech or muzzle. | How taken. | Number of specimen. | Position of specimen. | Elastic limit per square inch of original section. | Tensile strength per square inch of original section. | Elongation after rupture. | Reduction in area after rupture. |
|---|---|---|---|---|---|---|---|---|
| | | | | | *Pounds.* | *Pounds.* | *Per ct.* | *Per ct.* |
| 1 | Muzzle | Longitudinally | 1 | Middle | 46,000 | 86,800 | 19.00 | 50.64 |
| 1 | Breech | Tangentially | 1 | do | 47,000 | 88,000 | 20.00 | 43.41 |
| 2 | Muzzle | do | 1 | | 53,000 | 91,600 | 20.83 | 46.67 |
| 2 | Breech | Longitudinally | 1 | | 65,000 | 108,800 | 17.83 | 39.18 |

### *Jacket casting for 10-inch wire wound B. L. rifle.*

This casting was ordered April 13, and should have been delivered July 13, 1891; it has been molded, and will soon be cast.

### *Forgings for 3.6-inch B. L. field mortars.*

These forgings were ordered June 8, 1891; they are to be completed by December 8, 1891. At this date all the pieces have been forged and some are being rough-machined.

### *Forgings for 8-inch Haskell multicharge gun.*

The inspection of the manufacture and acceptance of these forgings is to be undertaken by Mr. J. R. Haskell, this office receiving the forgings on his notification that they are satisfactory as to physical qualities and dimensions. At this date none of the forgings have been made.

Very respectfully, your obedient servant,

F. E. HOBBS,
*Lieutenant, Ord. Dept., U. S. Army, Inspector.*

The CHIEF OF ORDNANCE, U. S. ARMY,
*Washington, D. C.*

# APPENDIX 27.

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## *REVISED SPECIFICATIONS GOVERNING THE MANUFACTURE OF STEEL FORGINGS FOR CANNON, PRESCRIBED BY THE ORDNANCE DEPARTMENT, U. S. ARMY.*

### PART I.—GENERAL SPECIFICATIONS.

#### *1. Inspection of the manufacture.*

The manufacture of material for ordnance constructions shall be open to inspection in all its details by the officers and employés of the Ordnance Department assigned to duty for that purpose, and must be satisfactory to the inspector at the works, or such one of his assistants as he may designate, at all its stages.

#### *2. Information and assistance to be given inspectors.*

That the requirements of paragraph 1 may be carried out the manufacturers shall, before commencing the work under any order or contract, inform the inspector of their general plans; and during the progress of the work they shall inform him of the chemical composition of each and every ingot, part of ingot, or casting which they propose to use, together with a statement of its casting, size, and condition; they shall inform him, or such of his assistants as he may designate, of the time at which each operation connected, either directly or indirectly, with the manfacture is to take place, and shall give him such notification as may be required to insure his witnessing any particular part of an operation which he may specify; they shall furnish him with a copy of the results of all chemical analyses and mechanical tests made at their works upon any piece under fabrication or in any way connected with the material to be furnished; they shall provide all necessary labor, and allow the use of the necessary tools and implements for the assistance of the inspector and his assistants in the performance of any of their duties; and they shall provide within their works suitable and satisfactory office room for instruments, drawings, records, etc., which may be used exclusively by the inspector and his assistants.

The officers and employés referred to in paragraph 1 shall have free access at all times to all parts of the manufacturers' works. The details of the operations carried on at the works will be considered confidential so far as the manufacturers may desire.

#### *3. Drawings and blank forms.*

All necessary drawings shall be provided by the manufacturers, and any copies of drawings furnished by the United States shall be examined by the inspector before they are issued for use at the works.

All drawings furnished by the United States shall be considered confidential and for the use of the manufacturers in the prosecution of the Government work only. All blank forms which may be necessary for the expeditious manufacture of the material, or to facilitate the transaction of business between the inspector and the manufacturers, shall be furnished by the manufacturers.

### 4. *Changes in contract drawings.*

The dimensions shown on the drawings accompanying contracts shall always be subject to such changes as the United States may deem advisable; but any changes which materially increase the cost of manufacture per pound shall be paid for at a fair price, to be determined by the contracting parties.

### 5. *Metal.*

The metal used shall be low steel, melted by the open-hearth process and cast into suitable ingots at the works of the manufacturers. For special purposes and for some small parts crucible steel shall be used when required.

### 6. *Marking forgings during manufacture.*

The manufacturers shall devise and use plans for marking forgings, pieces for forgings cut from ingots, etc., which shall determine with certainty that end or part of the forging, piece, etc., which was nearest to the top of the ingot as cast, and in case more than one piece is cut from any one ingot, the relative positions of the several pieces in the ingot and which shall in all cases assure the identification of the forging, piece, etc., with the ingot from which it was made or cut. They shall also determine with certainty the weight of metal cut from the top and from the bottom of each ingot used.

### 7. *Condition of material when delivered.*

All the forgings shall be rough finished, except when, for some parts of breech mechanism, it is specifically stipulated on the drawings that smooth forgings are required; they shall conform to the dimensions shown on the drawings, and must be free from seams, cracks, sand, slag, folds, or other defects.

### 8. *Allowance of metal for tests.*

The manufacturers shall always allow, without cost to the United States, sufficient additional length or size to the pieces to furnish the test specimens required. Subject to the limitations prescribed hereinafter, the instructions of the inspector relative to the allowance of metal for and positions of the test specimens shall be followed, and the manufacturers shall always ascertain these instructions before commencing the work.

Any metal required by the manufacturers for their own mechanical tests at the various stages of manufacture shall be provided for in additional length or size of the pieces over that required by the United States for the tests of acceptance, and in no case, unless by special authorization of the inspector, shall the manufacturers use for their own tests any of the metal or length of piece required by the United States.

### 9. *Submission for test.*

Pieces which have filled the requirements of manufacture and have been properly treated shall be submitted for test by the manufacturers, and the inspector shall then proceed to designate the positions of the required test specimens, marking them and the forging for future identification according to the instructions of the Chief of Ordnance. The marks put on the forgings at this time, or by the inspector at any time, should always be on the piece, and before they are effaced in one place must be transferred to some other place in the presence of the inspector.

### 10. *Test of specimens.*

If the manufacturers possess a satisfactory testing machine, and if the results obtained with such testing machine are found to be comparable with those obtained with the United States testing machine at Watertown Arsenal, then the Government specimens required shall be tested by the manufacturers, without charge, in the presence of the inspector, in the following manner:

Apply successively the loads stated in the following table, after which increase the successive loads by increments of 1,000 pounds per square inch until five loads beyond the elastic limit have been applied, then remove the micrometer and run up to the maximum load. Record the elongation under each applied load until the micrometer is removed. Release the load and record the permanent set after the application of the first and last two loads given in the table in each case, except for specimens from parts of breech mechanism, for which release only after the first and last loads given.

| For specimens from— | Loads, pounds per sq. inch. | For specimen from— | Loads, pounds per sq. inch. |
|---|---|---|---|
| Tubes | 5,000 | Cylindrical hoops | 5,000 |
| | 10,000 | | 10,000 |
| | 20,000 | | 25,000 |
| | 30,000 | | 45,000 |
| | 35,000 | | 50,000 |
| | 40,000 | | |
| | | Trunnion hoops | 5,000 |
| Jackets for cannon of 10-inch caliber and over. | 5,000 | | 10,000 |
| | 10,000 | | 25,000 |
| | 20,000 | | 45,000 |
| | 30,000 | | 48,000 |
| | 35,000 | | |
| | 40,000 | Breechblocks, spindles, etc | 5,000 |
| | 42,000 | | 25,000 |
| | | | 45,000 |
| Jackets for field, siege and 8-inch cannon. | 5,000 | | |
| | 10,000 | Gas-check cups, etc | 5,000 |
| | 20,000 | | 40,000 |
| | 30,000 | | 70,000 |
| | 35,000 | | |
| | 40,000 | Lever handles, breech plates, etc | 5,000 |
| | 44,000 | | 25,000 |
| | | | 40,000 |

Determine and record for all specimens:

The total elongation after rupture.
Diameter at point of rupture.
Position of rupture.
Character of fracture.
Elongation of inch sections.

The original notes of each test will be recorded on a sheet made out in the form which follows:

**TEST No.——** **DATE, ——, 189—**

*Record of tensile test made with ——. Testing Machine by —— of specimen from —— for ——.*

*[Length of stem ——; diameter of stem ——; area of cross-section —— marks ——.]*

| Applied loads. | Total elongation. | Remarks. |
|---|---|---|
| *Pounds.* | *Inches.* | Per set at 5,000 pounds per square inch.<br>Per set at —— pounds per square inch.<br>Per set at —— pounds per square inch. |

Total elongation after rupture, —— inches.
Diameter at point of rupture, —— inches.
Position of rupture, ——.
Character of fracture, ——.
Elongation of inch sections, —— ——.

—— ——.

This sheet will be signed by the engineer making the test and be handed to the inspector.

If the manufacturers have no satisfactory testing machine the Chief of Ordnance may provide for testing the required specimens on any machine satisfactory to the United States, and the cost shall be charged to the manufacturers and be deducted from any amounts which may become due them.

All specimens which are to be tested outside of the manufacturers' works, excepting those special additional specimens taken by the United States for information, shall be sent to the place of testing by the manufacturers, by express, at their own expense. Summaries of the reports of test of such specimens will be furnished to the manufacturers for their information; but reports of tests made at Watertown Arsenal shall be regarded as strictly confidential prior to their publication by the Government.

All specimens shall pass through the inspector's hands for inspection and record. The United States testing machine at Watertown Arsenal and tests made on it shall always be considered as standard, and any or all specimens shall be tested on it if desired by the United States.

The following tensile specimens, to be selected by the inspector from the number required by the specifications to be furnished, will always be tested at Watertown Arsenal, viz:

One from every 5th tube and jacket forging for field cannon.

One from every 3d tube and jacket forging for siege cannon.

One from each end of every 3d tube and jacket forging for cannon of 8 inches caliber and upward.

And the cost of testing and recording these specimens shall be paid direct by the manufacturers to the proper officer at Watertown Arsenal.

### 11. *Additional specimens required.*

Any special additional test specimens required by the United States for information or experiment shall be furnished by the manufacturers at actual cost of labor of preparation, with ten per centum added to cover wear, etc., of tools.

### 12. *Time allowed when pieces are not accepted or rejected.*

If a piece is not accepted on account of unsatisfactory physical qualities shown by the results of test of the first set of specimens and the manufacturers desire to again submit the piece they shall, within three days from the date they are informed of nonacceptance, notify the inspector to that effect. The United States reserves the right to refuse a second submission; and if such notification is not received within that time, or if the manufacturers are informed that they cannot retreat or retest the piece, they shall proceed to replace it.

If a piece after being submitted for test is finally rejected at the manufacturers' works on account of unsatisfactory physical qualities or dimensions, or on account of defects, or at any time after delivery on account of developed defects, then the manufacturers shall be allowed three months in the case of tubes and jackets for cannon of 8 inches caliber and upward; two months in the case of trunnion hoops for cannon of 8 inches caliber and upward and tubes and jackets for siege cannon; and one month in the case of all other pieces, from the date of notification of rejection, in which to deliver the replacing piece; and no penalty shall accrue under the contract for nondelivery of a set of forgings on account of the nondelivery of such replacing piece during the time allowed; but the full penalty for nondelivery of a set will accrue for all the time after the stipulated time of delivery during which there remains any undelivered piece of the set the nondelivery of which is not covered by the allowance of time for replacement.

When a piece is required to replace one rejected after delivery for developed defect, a penalty will accrue for nondelivery within the time allowed for replacement, such penalty to bear the same ratio to the penalty for nondelivery of a set as the weight of the piece bears to the weight of a set.

### 13. *Use of rejected pieces and transfer of pieces.*

Pieces which are rejected may, with the approval of the inspector, be used for the manufacture of other pieces, but simple transfer of a piece from one designation to another may be made by the manufacturers, at any time before presentation for final inspection, on notification to the inspector; provided that in any case all the requirements of manufacture for the piece as presented for final inspection must be fulfilled.

### 14. *Provisional acceptance.*

Pieces which have filled the requirements of manufacture and which are accepted as to physical qualities shall be immediately machined to rough finished dimensions for delivery and be presented for final inspection. If they are satisfactory as to dimensions and show no defects they will be provisionally accepted by the United States; but the manufacturers shall hold themselves liable to replace any piece which may be finally rejected at any time during machine finishing for any developed defect.

### 15. *Allowed variations in rough finished dimensions.*

The rough finished dimensions at delivery may vary plus or minus one-sixteenth of an inch on a side from the required rough finished dimensions. If any rough finished dimension is more than one-sixteenth of an inch on a side nearer to the finished dimension than is required, but there is in the inspector's opinion a fair probability that the forging can be finished to the required dimension, with possibly some additional cost, then the piece will be provisionally accepted with the conditions that the manufacturers shall pay any extra cost of machine finishing due to the erroneous dimension, and shall replace the piece as though rejected for a developed defect if the attempt to finish is unsuccessful on account of the erroneous dimension, paying the cost of all machine work lost in the attempt to finish; if there is more than one-sixteenth of an inch of surplus metal on a side on any rough finished dimension, the manufacturers shall machine off the surplus metal to the required rough finished dimension.

### 16. *Board to determine the gravity of defects.*

If a piece is condemned at any time for defects the manufacturers may, with the approval of the Department, submit the piece for the inspection of a board to consist, if practicable, of not less than three officers of the Ordnance Department, and the decision of said board, subject to the approval of the Chief of Ordnance, shall govern as to its acceptance or rejection; and the manufacturers may have a representative appear before said board.

### 17. *Shipment of rejected and replacing pieces.*

If a piece be finally rejected after leaving the manufacturers' works, the manufacturers shall ship the replacing piece, freight charges prepaid, to the place of rejection. The rejected piece will, if the manufacturers desire, be shipped back to them at their expense.

### 18. *Delivery.*

A piece shall be considered *delivered* when it is provisionally accepted by the United States. The manufacturers shall, at the request of the inspector, place such pieces, without charge, on board cars where they can be taken up by a convenient shipping line, for transportation by the United States, and shall be responsible for any damage up to the time of shipment. Shipments will be made by the United States as frequently as economy will permit.

### 19. *Weight of delivered pieces.*

The weight of all pieces for payment shall be determined by calculation from the required rough finished dimensions, assuming a cubic inch of steel to weigh 0.284 of a pound. Weights for shipment shall be determined on accurate scales which the inspector may verify at any time.

### 20. *Payments.*

When contracts require the delivery of pieces for the fabrication of more than one kind or caliber of cannon, or more than one set of pieces for a particular caliber, then payment for each set of pieces for each kind or caliber, or for each set for a particular caliber, will be made on completion of the delivery of each set of pieces, less five per centum to be retained by the United States until the completion of the whole contract, or of all the pieces for a particular caliber.

Payments shall be made on bills approved by the proper officers in the manner prescribed by law and regulation.

### *21. Liability of sureties.*

A contract for the manufacture of material for cannon shall be considered completed so far as the liability of the sureties is concerned only when all the pieces to be delivered under said contract have been so far machine finished as to preclude the possibility of the final rejection of any one of said pieces.

## PART II.—FOR TUBES AND JACKETS.

### *1. Size of ingot.*

Ingots for tubes shall have an area of cross-section in that part of the ingot used for the tube forging at least four times as great as the maximum area of cross-section of the rough forging, except that for tubes for cannon of 12 inches caliber and upward the area of cross-section of that part of the ingot used for the tube forging shall be at least three and one-half times as great as the maximum area of cross-section of the rough forging; the ingots for jackets shall have an area of cross-section in that part of the ingot used for the jacket forging at least three and one-half times as great as the maximum area of cross-section of the rough forging, except that for jackets for cannon of 12 inches caliber and upward the area of cross-section of that part of the ingot used for the jacket forging shall be at least three times as great as the maximum area of cross-section of the rough forging; and the ingots for lining tubes shall have an area of cross-section in that part of the ingot used for the lining-tube forging at least six times as great as the maximum area of cross-section of the rough forging. If bored ingots are used then the wall of the ingot shall be reduced by forging at least as much as to one-half of its original thickness.

### *2. Part of ingot to be used.*

Only so much of any ingot shall be used for tube and jacket forgings, including extra length for test specimens, as shall remain after at least six per centum of the total weight of the ingot has been cut from the bottom of the ingot, and at least thirty per centum from the top; but if any other method is used for producing ingots than the usual one of casting solid in open molds, the weight of metal to be cut from the top and bottom of ingots shall, if desired by the manufacturers, be determined by the Ordnance Department, by experiment, at the manufacturers' expense, with a view to utilizing so much of such ingots as shall be equal in all respects to that part of the usual ingot which manufacturers are permitted to use.

### *3. Treatment.*

Tubes and jackets shall be annealed at a high heat before oil-tempering and either after forging or after rough finishing, as may be desired by the United States. The heat will be at least as high as that to which the pieces are subsequently to be heated for oil-tempering.

The pieces shall, after rough boring and turning, be oil-tempered, and subsequently annealed at a temperature lower than that of tempering.

Every operation of tempering or annealing must be witnessed by the inspector or such of his assistants as he may designate, and if unsatisfactory in any way, retempering or reannealing shall be ordered in his discretion.

### 4. *Oil-tempering.*

Tubes and jackets shall generally be heated for oil tempering vertically and as evenly as possible; shall be immersed in the oil in the direction of their axes in such manner and with such arrangement that a current of oil will flow through the bore, and the operation shall always be performed on the whole of the piece, never on a part only.

### 5. *Annealing after oil-tempering.*

Tubes and jackets shall be heated for annealing as evenly as possible, and the operation shall always be performed on the whole of the piece, never on a part only; but if it be necessary, from the conditions in any case, to vary the degree of the heat at the ends, this variation must be uniform from one end to the other.

### 6. *Straightening.*

When after treatment pieces are found to be bent or warped to such an extent as to render straightening necessary, they shall be heated for this operation, and the straightening shall be followed by oil-tempering and subsequent annealing, or annealing simply, in the discretion of the inspector. Tubes and jackets when delivered shall be straight and true, free from serious warp or bend, the exterior being truly concentric with the bore. The amount of warp or bend that can be allowed will be determined by the inspector.

### 7. *Number, form, and position of test specimens.*

The stem of all test specimens shall, if possible, be taken within the finished interior and exterior surfaces of the piece prolonged.

Tangential tensile test specimens shall be furnished from each tube and jacket as specified in the following table, No. I:

*Table I.*

| Caliber of cannon. | Designation of piece. | Number of specimens from— | | Size of specimens. | | Minimum distance of axis from end of forging. |
|---|---|---|---|---|---|---|
| | | Breech end. | Muzzle end. | Length of stem. | Diameter of stem. | |
| | | | | *Inches.* | *Inches.* | *Inches.* |
| Field cannon of all calibers. | Tube | 2 | 2 | 2.0 | 0.505 | 1.15 |
| | Jacket, without trunnions. | 2 or | 2 | 2.0 | 0.505 | 1.15 |
| | Jacket, with trunnions. | 2 | 2 | 2.0 | 0.505 | 1.15 |
| Siege cannon of all calibers. | Tube | 2 | 2 | 2.0 | 0.505 | 1.25 |
| | Jacket | 3 | 2 | 3.0 | 0.564 | 1.25 |
| Seacoast cannon of 8-inch caliber and upward to 12-inch caliber. | Tube | 3 | 3 | 3.0 | 0.564 | 1.50 |
| | Jacket | 3 | 3 | 3.0 | 0.564 | 1.50 |
| Seacoast cannon of 12 inches caliber and over. | Tube | 3 | 3 | 3.0 | 0.564 | 1.50 |
| | Jacket | 4 | 4 | 3.0 | 0.564 | 1.50 |

All with screw-ends as required.

### 8. *Physical qualities.*

Each of the test specimens should show the physical qualities given in the following table, No. II, which the manufacturers shall aim to obtain:

*Table II.*

| Caliber of cannon. | Designation of piece. | Elastic limit. | Tensile strength. | Elongation after rupture. |
|---|---|---|---|---|
| | | *Lbs. per sq. inch.* | *Lbs. per sq. inch.* | *Per cent.* |
| Field cannon of all calibers | Tube | 46,000 | 86,000 | 22.0 |
| | Jacket | 50,000 | 93,000 | 19.0 |
| Siege cannon of all calibers | Tube | 46,000 | 86,000 | 20.0 |
| | Jacket | 50,000 | 93,000 | 18.0 |
| Seacoast cannon of 8-inch caliber | Tube | 46,000 | 86,000 | 19.0 |
| | Jacket | 50,000 | 93,000 | 17.0 |
| Seacoast cannon of 10-inch caliber and over | Tube | 46,000 | 86,000 | 19.0 |
| | Jacket | 48,000 | 90,000 | 17.0 |

The forgings shall, however, be accepted as to physical qualities, provided no one of the specimens shows results in any particular below the figures given in the following table, No. III:

*Table III.*

| Caliber of cannon. | Designation of piece. | Elastic limit. | Tensile strength. | Elongation after rupture. | Contraction of area. |
|---|---|---|---|---|---|
| | | *Lbs. per sq. inch.* | *Lbs. per sq. inch.* | *Per cent.* | *Per cent.* |
| Field cannon of all calibers | Tube | 42,000 | 78,000 | 20.0 | 35.0 |
| | Jacket | 46,000 | 86,000 | 17.0 | 30.0 |
| Siege cannon of all calibers | Tube | 42,000 | 78,000 | 18.0 | 30.0 |
| | Jacket | 46,000 | 86,000 | 16.0 | 27.0 |
| Seacoast cannon of 8-inch caliber | Tube | 42,000 | 78,000 | 17.0 | 30.0 |
| | Jacket | 46,000 | 85,000 | 16.0 | 27.0 |
| Seacoast cannon of 10-inch caliber and over. | Tube | 42,000 | 78,000 | 17.0 | 30.0 |
| | Jacket | 44,000 | 83,000 | 16.0 | 27.0 |

Except that for the calibers and pieces enumerated below, one, and only one specimen from each end may be in any one, and only one, particular lower in its qualities than the figures given in table No. III, but must not be in that particular, lower than the figures given in the following table, No. IV:

*Table IV.*

| Caliber of cannon. | Designation of piece. | Elastic limit. | Tensile strength. | Elongation after rupture. | Contraction of area. |
|---|---|---|---|---|---|
| | | *Lbs. per sq. inch.* | *Lbs. per sq. inch.* | *Per cent.* | *Per cent.* |
| Seacoast cannon of 8-inch caliber | Tube | 40,000 | 75,000 | 16.0 | 25.0 |
| | Jacket | 44,000 | 83,000 | 14.0 | 20.0 |
| Seacoast cannon of 10-inch caliber and over. | Tube | 40,000 | 75,000 | 15.0 | 22.0 |
| | Jacket | 42,000 | 80,000 | 13.5 | 20.0 |

In addition to the tensile tests prescribed, the tubes and jackets shall be submitted to a powder test, or hydraulic test, if desired by the United

States, with an interior pressure a little (about 1,000 pounds) less than their elastic resistance; and no weakness or defect should be developed by these tests. The manufacturers shall detach rings for mandrel or initial tension tests when in special cases they are notified that such rings are desired.

These additional tests will be made under the supervision of the Ordnance Department, and any extra expense incurred by the manufacturers will be paid for as provided in paragraph II, Part I.

### *9. Retesting.*

If a piece fails to fill the physical requirements of these specifications at either end it may generally be submitted for retest of the failing end or ends, but in such case no specimen may show results below the figures given in table No. III. If retreatment intervenes between the two submissions, complete tests of both ends shall be made, except for those pieces where the test of but one end is required originally, and the previous results will not be considered in deciding upon the acceptance or rejection of the piece. If a piece fails to fill the requirements on this second submission it shall be finally rejected, except when the inspector recommends and the Chief of Ordnance authorizes further treatment or testing.

## PART III.—FOR HOOPS.

### *1. Part of ingot to be used.*

Only so much of any ingot shall be used for hoop forgings, including extra length for test specimens, as shall remain after at least five per centum of the total weight of the ingot has been cut from the bottom of the ingot, and at least twenty-eight per centum from the top; but if any other method is used for producing ingots than the usual one of casting solid in open molds, the weight of metal to be cut from the top and bottom of ingots shall, if desired by the manufacturers, be determined by the Ordnance Department, by experiment, at the manufacturers' expense, with view to utilizing so much of such ingots as shall be equal in all respects to that part of the usual ingots which manufacturers are permitted to use.

### *2. Size of forgings.*

Cylindrical hoops may be either forged or rolled. The allowance of metal over the rough-finished diameters shall be as slight as possible, especially if the hoop forgings are to be treated as they come from the forge or rolls and without being machined.

Trunnion hoops shall vary as little as possible from the rough-finished diameters, and especially the rough-finished dimensions in the vicinity of the rimbases, and any surplus metal shall be removed before treatment.

The inspector may, in his discretion, require the reworking of any hoop on which there is an excessive allowance of metal in any part or throughout, or may require the removal of the surplus metal by machining before oil-tempering. Except for very thin hoop forgings, the allowance of metal, over the rough-finished diameters, when the forging is oil-tempered should not exceed one-quarter of an inch.

### 3. *Treatment.*

All hoops shall, if desired by the United States, be annealed at a high heat before oil-tempering. The heat will be at least as high as that at which the hoops are to be subsequently oil-tempered. The hoops shall then be oil-tempered and subsequently annealed at a temperature lower than that of oil-tempering.

Every operation of tempering or annealing must be witnessed by the inspector, or such of his assistants as he may designate, and if unsatisfactory in any way, retempering or reannealing shall be ordered in his discretion.

### 4. *Oil-tempering.*

All hoops shall be heated for oil-tempering as evenly as possible and shall be immersed in the oil in the direction of their axes, and the operation shall be performed on the whole of the piece, never on a part only.

### 5. *Annealing after oil-tempering.*

All hoops shall be heated for annealing as evenly as possible, and the operation shall always be performed on the whole of the piece, never on a part only.

### 6. *Number, position, and form of test specimens.*

The stem of all test specimens shall, if possible, be taken within the finished interior and exterior surfaces of the hoop prolonged.

Tangential tensile test specimens shall be furnished from each trunnion hoop, as specified in the following table, No. V.

*Table V.*

| Caliber of cannon. | Number of test specimens. | | Size of specimens. | | Minimum distance of axis from end of hoop. |
|---|---|---|---|---|---|
| | Breech end. | Muzzle end. | Length of stem. | Diameter of stem. | |
| | | | *Inches.* | *Inches.* | *Inches.* |
| Field cannon of all calibers | 2 or | 2 | 2.0 | 0.505 | 1.15 |
| Siege cannon of all calibers | 2 or | 2 | 3.0 | 0.564 | 1.25 |
| Seacoast guns of 8 and 10 inches caliber | 3 or | 3 | 4.0 | 0.564 | 1.25 |
| Seacoast guns of 12 inches caliber and over | 4 or | 4 | 4.0 | 0.564 | 1.25 |
| Mortars of 8 inches caliber and over | 3 or | 3 | 4.0 | 0.564 | 1.25 |

All with screw ends as required.

Tangential tensile test specimens shall be furnished from cylindrical hoop forgings, as specified in the following table, No. VI:

*Table VI.*

| Rough finished size of hoops in forging. | Number of test specimens. | | Size of specimens. | | Minimum distance of axis from end of forging. |
|---|---|---|---|---|---|
| | From each end. | From forging. | Length of stem. | Diameter of stem. | |
| | | | *Inches.* | *Inches.* | *Inches.* |
| Not more than 11" inside diameter. Not more than 50" long. | ........ | 2 | 2.0 | 0.505 | 1.15 |
| Not more than 11" inside diameter. More than 50" long. Not more than 120" long. | 2 | ........ | 2.0 | 0.505 | 1.15 |
| More than 11" inside diameter. Not more than 24" inside diameter. Not more than 75" long. | ........ | 3 | 3.0 | 0.564 | 1.25 |
| More than 11" inside diameter. Not more than 24" inside diameter. More than 75" long. Not more than 150" long. | 3 | ........ | 3.0 | 0.564 | 1.25 |
| More than 24" inside diameter. Not more than 36" inside diameter. Not more than 60" long. | ........ | 3 | 4.0 | 0.564 | 1.25 |
| More than 24" inside diameter. Not more than 36" inside diameter. More than 60" long. | 3 | ........ | 4.0 | 0.564 | 1.25 |
| More than 36" inside diameter. Not more than 60" long. | ........ | 4 | 4.0 | 0.564 | 1.25 |
| More than 36" inside diameter. More than 60" long. | 4 | ........ | 4.0 | 0.564 | 1.25 |

All with screw ends as required.

The distance of the axis of the specimen from the end of the forging for both trunnion hoops and cylindrical hoops shall be at least the "minimum distance" given in the tables plus one-half the excess of thickness of the wall of the forging at the place of the specimen, when oil-tempered, over the prescribed rough-finished thickness of the hoop.

But whenever a hoop forging is rotated about its axis during the final annealing operation so that the inspector is satisfied that a uniform temperature throughout each circumference is mechanically assured, the number of specimens required by table No. VI may, at the desire of the manufacturers and in the discretion of the inspector, be reduced; one specimen being taken from each tested end when the rough-finished inside diameter of the hoops in the forging is not more than 24 inches, and two being taken from each tested end when the rough-finished inside diameter is more than 24 inches.

Also, when hoop forgings made from the same ingot are arranged end to end for final annealing, the number and positions of the tested ends may, at the desire of the manufacturers and in the discretion of the inspector, be determined from the following condition, viz: That no part of any rough-finished hoop shall be more than 30 inches from the plane of the axes of the specimens of a tested end as arranged. In estimating the number of ends to be tested under this condition, a tested end or ends will be supposed placed at one or both ends of the row of hoops according as one or more than one end is tested, but the inspector may, at his discretion, select other forging ends for testing instead of these.

The failure of any tested end of a hoop forging to fill the requirements of the specifications as to physical qualities will be considered to apply to all the metal between this end and a tested end which fills these requirements, but the metal between two consecutive tested ends which fill these requirements shall be regarded as filling them also; provided that any untested hoop of a forging may be separately tested and the question of its acceptance or rejection decided by its test alone.

Before the inspector allows any departure from the requirements of table No. VI he must assure himself that the manufacturers are attaining a degree of uniformity in treatment to warrant the change; he may at any time return, in whole or in part, to the requirements of table No. VI, and should do so occasionally to check the skill of the manufacturers and the certainty of the methods employed.

### 7. *Physical qualities.*

The test specimens should show at each tested end the mean physical qualities given in the following table, No. VII, as a minimum.

*Table VII.*

FOR TRUNNION HOOPS.

| Size of specimens. | | Elastic limit. | Tensile strength. | Elongation after rupture. |
|---|---|---|---|---|
| Length of stem. | Diameter of stem. | | | |
| *Inches.* | *Inches.* | *Pounds per sq. inch.* | *Pounds per sq. inch.* | *Per cent.* |
| 2.0 | 0.505 | 50,000 | 90,000 | 18.0 |
| 3.0 | 0.564 | 50,000 | 90,000 | 15.0 |
| 4.0 | 0.564 | 50,000 | 90,000 | 13.0 |

FOR CYLINDRICAL HOOP FORGINGS.

| | | | | |
|---|---|---|---|---|
| 2.0 | 0.505 | 50,000 | 90,000 | 18.0 |
| 3.0 | 0.564 | 53,000 | 93,000 | 15.0 |
| 4.0 | 0.564 | 53,000 | 93,000 | 13.0 |

Provided that for trunnion hoops one specimen may be, in any one particular, below the figures stated in table No. VII, but not lower than 48,000 pounds per square inch in elastic limit, 88,000 pounds per square inch in tensile strength, or 1 per cent less than stated in elongation after rupture; and provided, further, that for cylindrical hoop forgings, when two specimens are taken from an end, neither should be lower in any particular than the figures stated in the table, and when more than two specimens are taken from an end, one of them, and no more, may be, in any one particular, below the figures stated in table No. VII, but not lower than 50,000 pounds per square inch in elastic limit, 90,000 pounds per square inch in tensile strength, or 1 per cent less than stated in elongation after rupture.

### 8. *Retesting.*

If any hoop forging fails to fill the physical requirements of these specifications at either end, it may generally be submitted for retest of the failing end or ends, in which case the number of specimens may, in the discretion of the inspector, be less than was originally required; but each one of a reduced number of specimens must show qualities as high as the mean qualities required. If retreatment intervenes between the two submissions, complete tests of the forging shall be made and the previous results will not be considered in deciding upon its acceptance or rejection. A forging failing to pass on this second submission shall be finally rejected, except when the inspector recommends, and the Chief of Ordnance authorizes, further treatment or testing.

### 9. *Definition of hoop.*

The term cylindrical hoop used in these specifications shall be construed to mean all those forgings which are to be used over a tube or jacket in constructing a gun, by whatever name they may be designated, either as hoop, ring, sleeve, etc., and also all bushings for the breech.

## PART IV.—FOR PARTS OF BREECH MECHANISM.

### 1. *Part of ingots to be used.*

Only so much of any ingot shall be used for breech mechanism forgings, including extra length for test specimens, as shall remain after at least five per centum of the total weight of the ingot has been cut from the bottom of the ingot, and at least twenty-eight per centum from the top; but if any other method is used for producing ingots than the usual one of casting solid in open molds, the weight of metal to be cut from the top and bottom of ingots shall, if desired by the manufacturers, be determined by the Ordnance Department, by experiment, at the manufacturers' expense, with view to utilizing so much of such ingots as shall be equal in all respects to that part of the usual ingot which manufacturers are permitted to use.

### 2. *Size of forgings.*

Parts of breech mechanism, excepting those expressly required by the drawings as smooth forgings, shall be rough finished before treatment; but the inspector may, in his discretion, if the conditions warrant it, waive this requirement entirely, or may only require the removal of any excessive allowance of metal, in places, by machining; parts, however, which are shown on the drawings bored or pierced shall always be bored or pierced before oil-tempering.

### 3. *Treatment.*

Parts of breech mechanism, or such of them as may be desired by the United States, shall be annealed at a high heat before oil-tempering. This heat will be at least as high as that at which the parts are to be subsequently oil-tempered. The parts shall then be oil-tempered and subsequently annealed at a temperature lower than that of tempering.

Every operation of tempering and annealing must be witnessed by the inspector or such of his assistants as he may designate, and if unsatisfactory in any way, retempering or reannealing shall be ordered, in his discretion.

### 4. *Oil-tempering.*

Parts of breech mechanism shall be heated for oil-tempering as evenly as possible, and immersed in the oil as required; the operation shall always be performed on the whole of the piece, never on a part only.

### 5. *Annealing after oil-tempering.*

Parts of breech mechanism shall be heated for annealing as evenly as possible, and the operation shall always be performed on the whole of the piece, never on a part only.

### 6. *Representative treatment and testing.*

The parts of breech mechanism of the same kind made from the same ingot shall, as much as possible, be treated together, and specimens for test shall be taken from one or more of the pieces to represent the whole, as specified in Table No. VIII; and in all such cases the proposed disposition of the pieces for the final annealing must be approved by the inspector before the operation is commenced.

The acceptance, nonacceptance, or rejection of the tested piece shall carry with it the acceptance, nonacceptance, or rejection of all the other pieces represented by the same test; but in case of nonacceptance or rejection, when there happens to be on any of the other pieces sufficient metal to allow it to be tested as required by the specifications it may be so tested and passed upon separately, and in case of nonacceptance when there are several pieces represented and no extra metal for test specimens, one or more of the pieces may be cut up for test to represent the remaining ones, if satisfactory to the inspector.

In all cases of representative treatment and testing the manufacturers shall arrange with the inspector the details of the fabrication before any work is done, and the inspector shall designate the pieces to be tested.

### 7. *Number, position, and form of test specimens.*

The stem of all specimens shall, if possible, be taken within the finished exterior and interior surfaces of the piece prolonged, or otherwise they shall be taken just outside the rough-finished lines of the the piece; the axis shall, if possible, always be at least 3 inches from the axis of the forging.

Test specimens shall be furnished from parts of breech mechanism as specified in the following table, No. VIII:

*Table VIII.*

| Name of part. | Caliber of cannon. | | | Size of specimen. | | Minimum distance of axis from surface of piece. |
|---|---|---|---|---|---|---|
| | Field cannon of all calibers. | Siege cannon of all calibers. | Seacoast cannon of 8 inches caliber and over. | Length of stem. | Diameter of stem. | |
| | | | | *Inches.* | *Inches.* | *Inches.* |
| Breechblock | One from every fifth. | One from every third. | ........ | 2.0 | 0.505 | 1.15 |
| | ........ | ........ | *Two from every second. | 3.0 | 0.564 | 1.25 |
| Spindle | One from stem of every fifth. | One from stem of every third. | ........ | 2.0 | 0.505 | |
| | ........ | ........ | One from rear of head of every second. | †3.0 | ‡0.564 | 1.25 |
| Lever handles, breech plates, and face plates. | One from every twelfth. | One from every fifth. | ........ | 2.0 | 0.505 | |
| | ........ | ........ | One from every third. | 3.0 | 0.564 | |
| Gas-check cups and gas-check rings. | One from one additional forging for test. To be made for each 10. | One from one additional forging for test. To be made for each 6. | ........ | 2.0 | 0.505 | 0.50 |
| | ........ | ........ | Two from one additional forging for test. To be made for each 4. | 3.0 | 0.564 | 0.75 |
| Block carriers | One from every twelfth. | One from every fifth. | ........ | 2.0 | 0.505 | 0.75 |
| Hinge pins, rollers, and bars for securing pins. | One from one additional forging for test. To be made for each 25. | One from every tenth. | ........ | 2.0 | 0.505 | |
| | ........ | ........ | One from every fifth. | 3.0 | 0.564 | |

* Read "one" for breech blocks for cannon of 8 and 10 inches caliber.
† Read "2.0" for spindles for cannon of 8 inches caliber.
‡ Read "0.505" for spindles for cannon of 8 inches caliber.

All with screw ends, as required.

When one (or more) specimen is required from each ten (or other number of) forgings, one specimen will also be required from any less number of forgings, and at least one forging from each ingot and kind of forging shall be tested.

### 8. *Physical qualities.*

The test specimens must show the physical qualities given in the following table, No. IX, as a minimum:

*Table IX.*

| Name of part. | Size of specimen. | | Elastic limit. | Tensile strength. | Elongation after rupture. |
|---|---|---|---|---|---|
| | Length of stem. | Diameter of stem. | | | |
| | *Inches.* | *Inches.* | *Pounds per sq. inch.* | *Pounds per sq. inch.* | *Per cent.* |
| Breechblocks, spindles, hinge pins, and rollers. | 2.0 | 0.505 | 45,000 | 85,000 | 18.0 |
| | 3.0 | 0.564 | 45,000 | 85,000 | 16.0 |
| Lever handles, breech plates, face plates, and block carriers. | 2.0 | 0.505 | 40,000 | 75,000 | 20.0 |
| | 3.0 | 0.564 | 40,000 | 75,000 | 18.0 |
| Gas-check cups, gas-check rings, and bars for securing pins. | 2.0 | 0.505 | 70,000 | 125,000 | 12.0 |
| | 3.0 | 0.564 | 70,000 | 125,000 | 10.0 |

### 9. *Retesting.*

If any piece fails to fill the physical requirements of these specifications it may generally be submitted for retest, and if retreatment intervenes between the two submissions the previous results will not be considered in deciding upon the acceptance or rejection of the piece. Failing to fill the physical requirements on this second submission or any subsequent one, the piece may be finally rejected.

When tests are representative, retesting shall be subject to the conditions, requirements, and limitations of paragraph 6 of these specifications for parts of breech mechanism.

### 10. *Parts required as smooth forgings.*

Those parts of breech mechanism required by the drawings as smooth forgings or as simple castings, and for which no requirement as to physical qualities is specified, shall be made with great care, shall conform as nearly as practicable to the dimensions shown on the drawings, and shall be made of metal satisfactory to the inspector. Such parts shall be annealed after forging or casting and shall receive no other treatment.

D. W. Flagler,
*Brig. Gen., Chief of Ordnance, U. S. Army.*

Ordnance Office, War Department,
*Washington, D. C., March 31, 1891.*

# APPENDIX 28.

## *CONSTRUCTION REPORT ON THE MANUFACTURE OF 20 METALLIC CARRIAGES FOR MACHINE GUNS AND 20 MOUNTS FOR GATLING GUN, MODEL 1890, AT SPRINGFIELD ARMORY, SPRINGFIELD, MASS.*

(Four plates.)

These carriages are made of 0.15 inch low steel plate, after a design of the undersigned, by order (of July 17, 1889) of the Chief of Ordnance.

The design includes a spherical shield above and a plane apron below the axle for protection of gunners. The latter is hinged to the axle to be folded up and keyed to the underside of trail when not in action. The former can be removed from the carriage if desired; but it is properly a permanent part of the carriage, which without it is odd looking and makes obscure the motive of the construction. The accompanying plates, marked III and IV, of two perspective views of the carriage present it with shield and apron as designed.

The 20 carriages manufactured are without shields and aprons. Although the Department was advised of the anomalous appearance the carriages would have, the order for the manufacture was given. Why the shields and aprons are not—could not be put—on them is the kind of metal required for them has not yet been determined. The motive for the whole construction may be stated as follows:

To provide a permanent shield on the carriage that would permit all the elevation, depression, and traverse of gun attainable with a carriage without shield and ammunition boxes on top.

To provide a carriage without ammunition boxes, yet with equivalent means of carrying ammunition, the carriage on top, to be without obstruction of any kind limiting the traverse.

To provide a carriage and mount without complications in elevating and traversing devices, these to be the simplest possible as to parts and manipulation.

The carriage being (felloes and spokes of wheels excepted) metallic is, for ordinary wear and tear of service, indestructible. With shield and apron the weight is inconsiderable as to effect on mobility. The front of the top of body is an arc of a circle of the sphere of which the shield is a part. The body (resembling a box beam in construction) is the axle, and it and part of the trail make a chest for ammunition, in which about 1,200 caliber .45 service cartridges (in paper boxes as put up for service) can be carried for use when all other supplies are exhausted or unavailable. Two doors, right and left of trail, on the inner side, give access to the cartridge space in the body and a door on top of the upper end of trail to the cartridge space in the trail, the two parts being continuous—no partition between. Lower down in the trail is a tool box (and more space if desired for cartridges) to which the trail seat, when raised, gives access. The top of the carriage makes a convenient table, bordered by flange of angle iron used in the construction, on which tools, feed guides, and ammunition can be placed for use when in action.

The carriage is designed for any machine gun, each kind of gun to be provided with its own mount adapted to the carriage.

The Gatling gun, model 1890, is provided with a traversing and elevating lever, which is pivoted to the mount provided for that gun (the only mount yet devised and provided for this carriage). This lever passes through a rotating slide, provided with a clamp, attached to the gun. A slight turn of this clamp secures the gun in any position of elevation or depression. Between the arms of the mount, under the gun, is a clamp handle, a slight turn of which clamps the mount in any position of traverse, securely, so far as motion of the mount is affected by turning the crank in firing, but not so tight but that in action, should it be necessary to suddenly traverse the gun to another firing point without time to unclamp the mount, or in the hurry and excitement of action the gunner forget the clamp, the gun can be readily traversed by means of the lever.

The shield has a rectangular aperture corresponding to the sweep, horizontal and vertical, of the gun—the traverse and elevation and depression, the same with or without a shield. A rectangular frame corresponding to the aperture in the shield, and fitted in and free to move on horizontal ways, or slides, on it, travels horizontally, with the gun; a vertical part of the frame on each side being the means by which this motion is given—the gun in traversing bearing against these parts. These parts carry on journals attached to them, around which the circles are free to turn, two circles—disks—of metal, considerably thicker than the main shield. A radial portion, corresponding in width to the diameter of the gun near the muzzle, being removed from each disk, an aperture, when the disks are revolved about their centers until the removed portions correspond, or overlap, is made for the muzzle to project to the front. This will be readily understood by an inspection of the aforesaid plates III and IV.

These disks in any position of traverse completely cover the aperture in the fixed shield, the disks and frame to which they are attached constituting the movable portion operated automatically by the gun when traversed, elevated, or depressed.

When traversed the frame and disks move together; when elevated or depressed the disks move—turn—only about the journals. If gun be traversed and elevated or depressed at the same time both motions are combined.

All the plate and angle portions of the carriage are cut to form and length, drilled for rivets, and bent to shape.

The forged parts are forged and finished by planing, turning, and drilling, as required for each. The cast-bronze parts are cast from patterns, and such portions as require finishing are planed, "grubbed," bored, and drilled accordingly.

The parts are then assembled by riveting. In this work, except perhaps in one particular, there is nothing peculiar, and it all may be done in any ordinary machine shop with a forging department attached.

The exception is the operation of cutting the circular edge of the top and bottom carriage body plates. This is done on an ordinary planer, with a fixture having a fixed center independent of the planer, which moves the plate in a circle under the planer tool. The limbers for these carriages were principally designed and constructed under the supervision of Bvt. Col. E. B. Williston, major, Third United States Artillery, at Watervliet Arsenal.

A. R. BUFFINGTON,
*Colonel, Ord. Dept., U. S. Army.*

SPRINGFIELD ARMORY,
*Springfield, Mass., October 2, 1891.*

*Bills of material and nomenclature for metallic carriage for machine guns and mount for Gatling gun, model 1890.*

| Number of parts in carriage. | Name of parts. | Number of pieces required. | Dimensions. | | | Material. |
|---|---|---|---|---|---|---|
| | | | Length. | Width. | Thickness. | |
| | | | *Inches.* | *Inches.* | *Inches.* | |
| 1 | Upper plate (body) | 1 | 51 | 25½ | 0.15 | Low steel. |
| 1 | Lower plate (body) | 1 | 51 | 20½ | 0.15 | |
| 1 | Front plate (body) | 1 | 55 | 5½ | 0.15 | |
| 2 | Doors (body) | To be cut from upper and lower body plates. | | | | |
| 2 | Rear end plates (body) | | | | | |
| 2 | Rear inside plates (body) | | | | | |
| 2 | Side plates (trail) | 2 | 57 | 6 | 0.15 | |
| 2 | Top and bottom plates (trail) | 1 | 52 | 16½ | 0.15 | |
| 1 | Transom (trail) | 1 | 11½ | 4½ | 0.15 | |
| 1 | Lower trail door and seat | 1 | 15½ | 6 | 0.125 | |
| 1 | Lower trail, door and seat hinge plate. | 1 | 6 | 1½ | 0.125 | |
| 1 | Upper trail door | 1 | 10½ | 7 | 0.125 | |
| 5 | Angle irons, for body | 4 | 56 | 1½ | 1½ | 4 pounds per yard. Good wrought iron or low steel. |
| 2 | Angle irons for trail | 2 | 59½ | 1½ | 1½ | |
| 2 | Angle irons for trail | 2 | 57 | 1½ | 1½ | |
| 1 | T-iron (axle stock) | 1 | 51 | 2½ | 2½ | 16 pounds per yard. |
| 2 | Axle ends or spindles | 2 | 10 | 3¾ | 3¾ | Low steel. |
| 1 | Lunette (shoe piece) | 1 | 11 | 4 | 1 | |
| 1 | Lunette (plate and handspike attachment). | 1 | 8 | 4 | 2½ | |
| 1 | Seat prop | 1 | 4 | 1½ | ½ | |
| 1 | Seat prop hinge strap | 1 | 1½ | 1½ | ¼ | |
| 1 | Seat prop rest | 1 | 5 | 2½ | ³⁄₁₆ | |
| 8 | Hinges | 1 | 16 | 1½ | ¼ | Low steel or good iron. |
| 9 | Hinge pins | 1 | 16 | 0.20 | wire. | |
| 56 | Rivets for hinges and seat prop. | 1 | 40 | 0.20 | wire. | |
| 2 | Trail handles | 1 | 24 | ½ | round. | Low steel. |
| 1 | Upper trail door key | 1 | 2 | 1½ | ¼ | Good iron or low steel. |
| 1 | Upper trail door key eyebolt | 1 | 1½ | 1 | ¼ | |
| 1 | Upper trail door key chain | 1 | 5½ | ½ | wire twist link. | |
| 2 | Upper trail door key chain rings. | 1 | 6 | 0.15 | wire. | |
| 1 | Upper trail door key chain eye pin. | 1 | ¾ | ½ | ¼ | |
| 2 | Turn-buckles (for body doors) | ..... | ..... | ..... | ..... | 6 ounces, cast bronze. |
| 2 | Turn-buckle studs | 1 | 2½ | ½ | round. | |
| 1 | Trail handspike handle | 1 | 34 | 1 | ..... | Gaspipe, wrought iron. |
| | Attachment end | 1 | 7 | 1½ | 1½ | Low steel. |
| 1 | Trail handspike bolt | 1 | 3 | 1½ | round. | |
| 1 | Trail handspike bolt key | 1 | ½ | 0.15 | wire. | Low steel or good iron. |
| 1 | Trail handspike bolt nut | 1 | Hexagon for ½-inch bolt. | | | Good iron. |
| 2 | Linch washers | 1 | 14½ | ½ | ¼ | Low steel. |
| 2 | Linchpins | 1 | 4½ | 1½ | ¼ | |
| 2 | Linchpin clasps | 1 | 5 | ½ | ³⁄₁₆ | |
| 2 | Linchpin clasp rivets | 1 | 2 | ½ | round. | Low steel or good iron. |
| 1 | Pintle socket for mount | ..... | ..... | ..... | ..... | 32 pounds, cast bronze. |
| 2 | Pintle socket stop pins | 1 | 3 | ½ | round. | Low steel. |
| 251 | Rivets | 1 | 32.0 | ³⁄₁₆ | round. | Low steel or good iron. |
| 4 | Rivets | 1 | 8 | ¼ | round. | |
| 12 | Axle bolts | 1 | 5.0 | ½ | round. | |
| 12 | Axle bolt nuts | 12 | Hexagon for ⁷⁄₁₆ bolts. | | | Good iron. |
| 4 | Axle quoins | 2 | 4½ | 3½ | ½ | Low steel or good iron. |
| 2 | Wheels—special pattern of patented wheel made to order by the Archibald Wheel Co., Lawrence, Mass. | 2 | For dimensions see plate No. VIII of working drawings. | | | Tire, low steel; nave boxes and flanges, malleable iron; fellies and spokes, oak; dowels, wrought iron; nave box bolts and nuts, wrought iron. |

### *Mount for Gatling gun, model 1890.*

| No. of pieces. | Name of component. | Length. | Diameter. | Weight in pounds. | Material. |
|---|---|---|---|---|---|
| | | *Inches.* | *Inches.* | | |
| 1 | Mount, body | | | 66 | Cast bronze. |
| 2 | Cap squares | | | 4⅛ | Do. |
| 2 | Hinge pins | | 0.51 | | Low steel. |
| 2 | Locking keys | 6 | 1. | | |
| 2 | Locking-key securing screws | 1¼ | .25 | | |
| 1 | Clamp screw | 12⅞ | 1.50 | | |
| 1 | Clamp-screw handle | | | 2¼ | Cast bronze. |
| 1 | Clamp-screw handle pin | 1 7/16 | .1875 | | Low steel. |
| 1 | Clamp-screw stop pin | ⅝ | .22 | | Do. |
| 1 | Clamp-screw washer nut | | | 3⅝ | Cast bronze. |
| 1 | Clamp-screw washer nut securing screw pin | 1¼ | .6875 | | Low steel. |
| 1 | Clamp-screw stop washer | ⅝ | 1.375 | ¼ | Cast bronze. |
| 1 | Clamp-screw stop washer pin | ¼ | .10 | | Low steel. |

(6759–'91.)

## NOMENCLATURE OF METALLIC CARRIAGE AND LIMBER FOR MACHINE GUNS, MANUFACTURED AT SPRINGFIELD ARMORY.

### CARRIAGE.

Wheels (Archibald):
- Tire.
- Felloes, bolts, and nuts.
- Spokes.
- Nave boxes.
- Nave-box flanges.
- Nave-box bolts and nuts.
- Dowels.

Body (which is also the axle body and forms the cartridge compartment):
- Upper plate.
- Lower plate.
- Front plate.
- Rear plates: Inside—right and left. Outside—right and left.
- Cartridge-compartment doors, hinges and pins.
- Cartridge-compartment door turnbuckles and studs.
- Pintle socket (for mount).
- Pintle socket stop pins.
- Axle spindles.
- Axle-spindle bolts and nuts.
- Axle T-iron.
- Axle quoins.
- Angle irons.
- Rivets.
- Linch washers.
- Linchpins.
- Linchpin clasps and rivets.

Trail:
- Top plate.
- Bottom plate.
- Side plates.
- Transom.
- Upper door.
- Upper-door hinges and pins.
- Upper-door key.
- Upper-door key eyebolt.
- Upper-door key chain.
- Upper-door key-chain rings.
- Upper-door key-chain eye pin.
- Lower door and seat.
- Lower-door and seat-plate hinges and pins.

Trail—Continued.
- Seat prop.
- Seat-prop hinge, strap, and pin.
- Seat-prop rest.
- Lunette.
- Lunette plate and handspike attachment.
- Handspike.
- Handspike bolt and nut.
- Handles.
- Angle irons.
- Rivets.

Shield:
- Shield.
- Shield attachments, bolts, and nuts.
- Aperture ways.
- Disks.
- Disk carrier.
- Disk journals, washers, and nuts.

Apron:
- Apron.
- Apron hinges and pins.
- Turn-buckle and stud (on bottom plate of trail).

### *Mount for Gatling gun, model 1890.*

Mount:
- Body.
- Cap squares.
- Hinge pins.
- Locking keys.
- Locking-key securing screws.
- Clamp-screw.
- Clamp-screw handle.
- Clamp-screw handle pin.
- Clamp-screw stop pin.
- Clamp-screw washer nut.
- Clamp-screw washer nut securing screw pin.
- Clamp-screw stop washer.
- Clamp-screw stop-washer pin.

## NOMENCLATURE OF METALLIC CARRIAGE AND LIMBER FOR MACHINE GUNS, ETC.—Continued.

### LIMBER.

- Wheels (Archibald):
  - Tire, with bolts, nuts, and washers.
  - Felloes, with rivets and burrs.
  - Spokes.
  - Nave boxes.
  - Nave-box flanges.
  - Nave-box bolts and nuts.
  - Dowels.
- Body (metal) and connected parts:
  - Axle.
  - Linchpins, with clasps.
  - Linch washers.
  - Hounds.
  - Fork.
  - Crossbar.
  - Understraps, attaching fork and hounds to axle and crossbar to fork.
  - Corner brackets, connecting crossbar to hounds.
  - Pintle, with bolts and nuts connecting pintle to rear end of fork.
  - Pintle key and chain.
  - Pole prop.
  - Pole-prop eye.
  - Pole-prop spring.
  - Footboards, metal.
  - Rack in front of chest, with three standards riveted to body, and four bolts with nuts attaching rack to front of chest.

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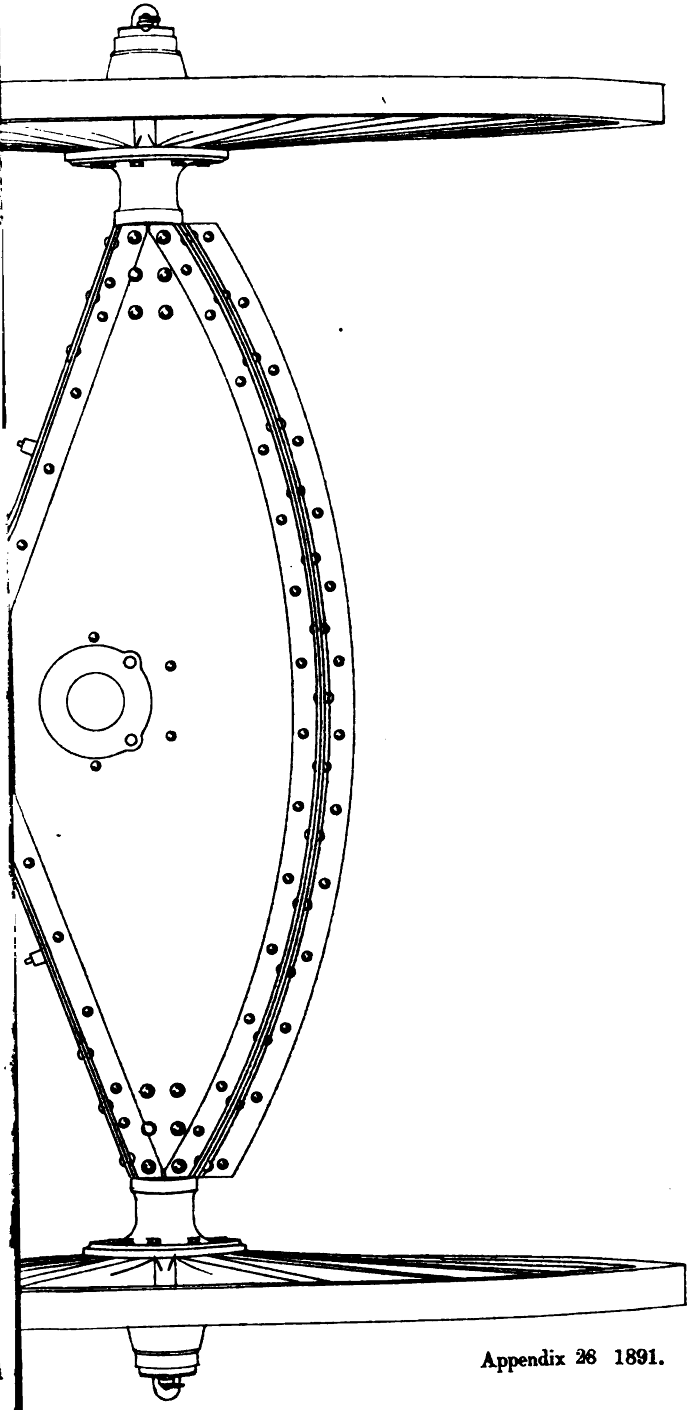
- Body (metal) and connected parts—Continued.
  - Pole, with shoe and neck-yoke stop.
  - Pole key, with safety spring.
  - Doubletree bolt, with stay and stay bolts.
  - Doubletree stay chains.
  - Doubletree, wood, ironed.
  - Singletrees, wood, ironed.
  - Neck-yoke, wood, ironed.
  - Pole pad.
  - Neck-yoke pads.
- Ammunition chest (wood, ironed):
  - Chest.
  - Lid.
  - Hinges.
  - Hasp.
  - Turn-buckle and stud.
  - Corner irons.
  - End irons.
  - Shield.
  - Canvas cover on lid.
  - Paulin straps on lid.
  - Two wooden partitions, dividing interior into three compartments.
  - Copper strips covering hinge and hasp straps.
  - Bolts, nuts, and plates to attach chest to body.

ME

PLATE I.



Appendix 26 1891.

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*Mount for Gatling gun, model 1890.*

| No. of pieces. | Name of component. | Length. | Diameter. | Weight in pounds. | Material. |
|---|---|---|---|---|---|
| | | *Inches.* | *Inches.* | | |
| 1 | Mount, body | ........ | ....... | 66 | Cast bronze. |
| 2 | Cap squares | ........ | ....... | 4½ | Do. |
| 2 | Hinge pins | ........ | 0.51 | .......... | Low steel. |
| 2 | Locking keys | 6 | 1. | .......... | |
| 2 | Locking-key securing screws | 1¼ | .25 | .......... | |
| 1 | Clamp screw | 12⅞ | 1.50 | .......... | |
| 1 | Clamp-screw handle | ........ | ....... | 2¼ | Cast bronze. |
| 1 | Clamp-screw handle pin | 1 7/16 | .1875 | .......... | Low steel. |
| 1 | Clamp-screw stop pin | ⅝ | .22 | .......... | Do. |
| 1 | Clamp-screw washer nut | ........ | ....... | 3¾ | Cast bronze. |
| 1 | Clamp-screw washer nut securing screw pin | 1¼ | .6875 | .......... | Low steel. |
| 1 | Clamp-screw stop washer | ⅜ | 1.375 | ¼ | Cast bronze. |
| 1 | Clamp-screw stop washer pin | ¾ | .10 | .......... | Low steel. |

(6759–'91.)

## NOMENCLATURE OF METALLIC CARRIAGE AND LIMBER FOR MACHINE GUNS, MANUFACTURED AT SPRINGFIELD ARMORY

### CARRIAGE.

Wheels (Archibald):
- Tire.
- Felloes, bolts, and nuts.
- Spokes.
- Nave boxes.
- Nave-box flanges.
- Nave-box bolts and nuts.
- Dowels.

Body (which is also the axle body and forms the cartridge compartment):
- Upper plate.
- Lower plate.
- Front plate.
- Rear plates: Inside—right and left. Outside—right and left.
- Cartridge-compartment doors, hinges and pins.
- Cartridge-compartment door turnbuckles and studs.
- Pintle socket (for mount).
- Pintle socket stop pins.
- Axle spindles.
- Axle-spindle bolts and nuts.
- Axle T-iron.
- Axle quoins.
- Angle irons.
- Rivets.
- Linch washers.
- Linchpins.
- Linchpin clasps and rivets.

Trail:
- Top plate.
- Bottom plate.
- Side plates.
- Transom.
- Upper door.
- Upper-door hinges and pins.
- Upper-door key.
- Upper-door key eyebolt.
- Upper-door key chain.
- Upper-door key-chain rings.
- Upper-door key-chain eye pin.
- Lower door and seat.
- Lower-door and seat-plate hinges and pins.

Trail—Continued.
- Seat prop.
- Seat-prop hinge, strap, and pin.
- Seat-prop rest.
- Lunette.
- Lunette plate and handspike attachment.
- Handspike.
- Handspike bolt and nut.
- Handles.
- Angle irons.
- Rivets.

Shield:
- Shield.
- Shield attachments, bolts, and nuts.
- Aperture ways.
- Disks.
- Disk carrier.
- Disk journals, washers, and nuts.

Apron:
- Apron.
- Apron hinges and pins.
- Turn-buckle and stud (on bottom plate of trail).

*Mount for Gatling gun, model 1890.*

Mount:
- Body.
- Cap squares.
- Hinge pins.
- Locking keys.
- Locking-key securing screws.
- Clamp-screw.
- Clamp-screw handle.
- Clamp-screw handle pin.
- Clamp-screw stop pin.
- Clamp-screw washer nut.
- Clamp-screw washer nut securing screw pin.
- Clamp-screw stop washer.
- Clamp-screw stop-washer pin.

## NOMENCLATURE OF METALLIC CARRIAGE AND LIMBER FOR MACHINE GUNS, ETC.—Continued.

### LIMBER.

- Wheels (Archibald):
  - Tire, with bolts, nuts, and washers.
  - Felloes, with rivets and burrs.
  - Spokes.
  - Nave boxes.
  - Nave-box flanges.
  - Nave-box bolts and nuts.
  - Dowels.
- Body (metal) and connected parts:
  - Axle.
  - Linchpins, with clasps.
  - Linch washers.
  - Hounds.
  - Fork.
  - Crossbar.
  - Understraps, attaching fork and hounds to axle and crossbar to fork.
  - Corner brackets, connecting crossbar to hounds.
  - Pintle, with bolts and nuts connecting pintle to rear end of fork.
  - Pintle key and chain.
  - Pole prop.
  - Pole-prop eye.
  - Pole-prop spring.
  - Footboards, metal.
  - Rack in front of chest, with three standards riveted to body, and four bolts with nuts attaching rack to front of chest.
- Body (metal) and connected parts—Continued.
  - Pole, with shoe and neck-yoke stop.
  - Pole key, with safety spring.
  - Doubletree bolt, with stay and stay bolts.
  - Doubletree stay chains.
  - Doubletree, wood, ironed.
  - Singletrees, wood, ironed.
  - Neck-yoke, wood, ironed.
  - Pole pad.
  - Neck-yoke pads.
- Ammunition chest (wood, ironed):
  - Chest.
  - Lid.
  - Hinges.
  - Hasp.
  - Turn-buckle and stud.
  - Corner irons.
  - End irons.
  - Shield.
  - Canvas cover on lid.
  - Paulin straps on lid.
  - Two wooden partitions, dividing interior into three compartments.
  - Copper strips covering hinge and hasp straps.
  - Bolts, nuts, and plates to attach chest to body.

(8103–'91.)

*Mount for Gatling gun, model 1890.*

| No. of pieces. | Name of component. | Length. | Diameter. | Weight in pounds. | Material. |
|---|---|---|---|---|---|
| | | *Inches.* | *Inches.* | | |
| 1 | Mount, body | ........ | ........ | 66 | Cast bronze. |
| 2 | Cap squares | ........ | ........ | 4½ | Do. |
| 2 | Hinge pins | ........ | 0. 51 | .......... | Low steel. |
| 2 | Locking keys | 6 | 1. | .......... | |
| 2 | Locking-key securing screws | 1¼ | . 25 | .......... | |
| 1 | Clamp screw | 12⅞ | 1. 50 | .......... | |
| 1 | Clamp-screw handle | ........ | ........ | 2¼ | Cast bronze. |
| 1 | Clamp-screw handle pin | 1 7/16 | . 1875 | .......... | Low steel. |
| 1 | Clamp-screw stop pin | ⅝ | . 22 | .......... | Do. |
| 1 | Clamp-screw washer nut | ........ | ........ | 3¾ | Cast bronze. |
| 1 | Clamp-screw washer nut securing screw pin | 1¼ | . 6875 | .......... | Low steel. |
| 1 | Clamp-screw stop washer | ⅜ | 1. 375 | ½ | Cast bronze. |
| 1 | Clamp-screw stop washer pin | ¼ | . 10 | .......... | Low steel. |

(6759–'91.)

## NOMENCLATURE OF METALLIC CARRIAGE AND LIMBER FOR MACHINE GUNS, MANUFACTURED AT SPRINGFIELD ARMORY

### CARRIAGE.

- Wheels (Archibald):
  - Tire.
  - Felloes, bolts, and nuts.
  - Spokes.
  - Nave boxes.
  - Nave-box flanges.
  - Nave-box bolts and nuts.
  - Dowels.
- Body (which is also the axle body and forms the cartridge compartment):
  - Upper plate.
  - Lower plate.
  - Front plate.
  - Rear plates: Inside—right and left. Outside—right and left.
  - Cartridge-compartment doors, hinges and pins.
  - Cartridge-compartment door turnbuckles and studs.
  - Pintle socket (for mount).
  - Pintle socket stop pins.
  - Axle spindles.
  - Axle-spindle bolts and nuts.
  - Axle T-iron.
  - Axle quoins.
  - Angle irons.
  - Rivets.
  - Linch washers.
  - Linchpins.
  - Linchpin clasps and rivets.
- Trail:
  - Top plate.
  - Bottom plate.
  - Side plates.
  - Transom.
  - Upper door.
  - Upper-door hinges and pins.
  - Upper-door key.
  - Upper-door key eyebolt.
  - Upper-door key chain.
  - Upper-door key-chain rings.
  - Upper-door key-chain eye pin.
  - Lower door and seat.
  - Lower-door and seat-plate hinges and pins.
- Trail—Continued.
  - Seat prop.
  - Seat-prop hinge, strap, and pin.
  - Seat-prop rest.
  - Lunette.
  - Lunette plate and handspike attachment.
  - Handspike.
  - Handspike bolt and nut.
  - Handles.
  - Angle irons.
  - Rivets.
- Shield:
  - Shield.
  - Shield attachments, bolts, and nuts.
  - Aperture ways.
  - Disks.
  - Disk carrier.
  - Disk journals, washers, and nuts.
- Apron:
  - Apron.
  - Apron hinges and pins.
  - Turn-buckle and stud (on bottom plate of trail).

*Mount for Gatling gun, model 1890.*

- Mount:
  - Body.
  - Cap squares.
  - Hinge pins.
  - Locking keys.
  - Locking-key securing screws.
  - Clamp-screw.
  - Clamp-screw handle.
  - Clamp-screw handle pin.
  - Clamp-screw stop pin.
  - Clamp-screw washer nut.
  - Clamp-screw washer nut securing screw pin.
  - Clamp-screw stop washer.
  - Clamp-screw stop-washer pin.

## NOMENCLATURE OF METALLIC CARRIAGE AND LIMBER FOR MACHINE GUNS, ETC.—Continued.

### LIMBER.

- Wheels (Archibald):
  - Tire, with bolts, nuts, and washers.
  - Felloes, with rivets and burrs.
  - Spokes.
  - Nave boxes.
  - Nave-box flanges.
  - Nave-box bolts and nuts.
  - Dowels.
- Body (metal) and connected parts:
  - Axle.
  - Linchpins, with clasps.
  - Linch washers.
  - Hounds.
  - Fork.
  - Crossbar.
  - Understraps, attaching fork and hounds to axle and crossbar to fork.
  - Corner brackets, connecting crossbar to hounds.
  - Pintle, with bolts and nuts connecting pintle to rear end of fork.
  - Pintle key and chain.
  - Pole prop.
  - Pole-prop eye.
  - Pole-prop spring.
  - Footboards, metal.
  - Rack in front of chest, with three standards riveted to body, and four bolts with nuts attaching rack to front of chest.

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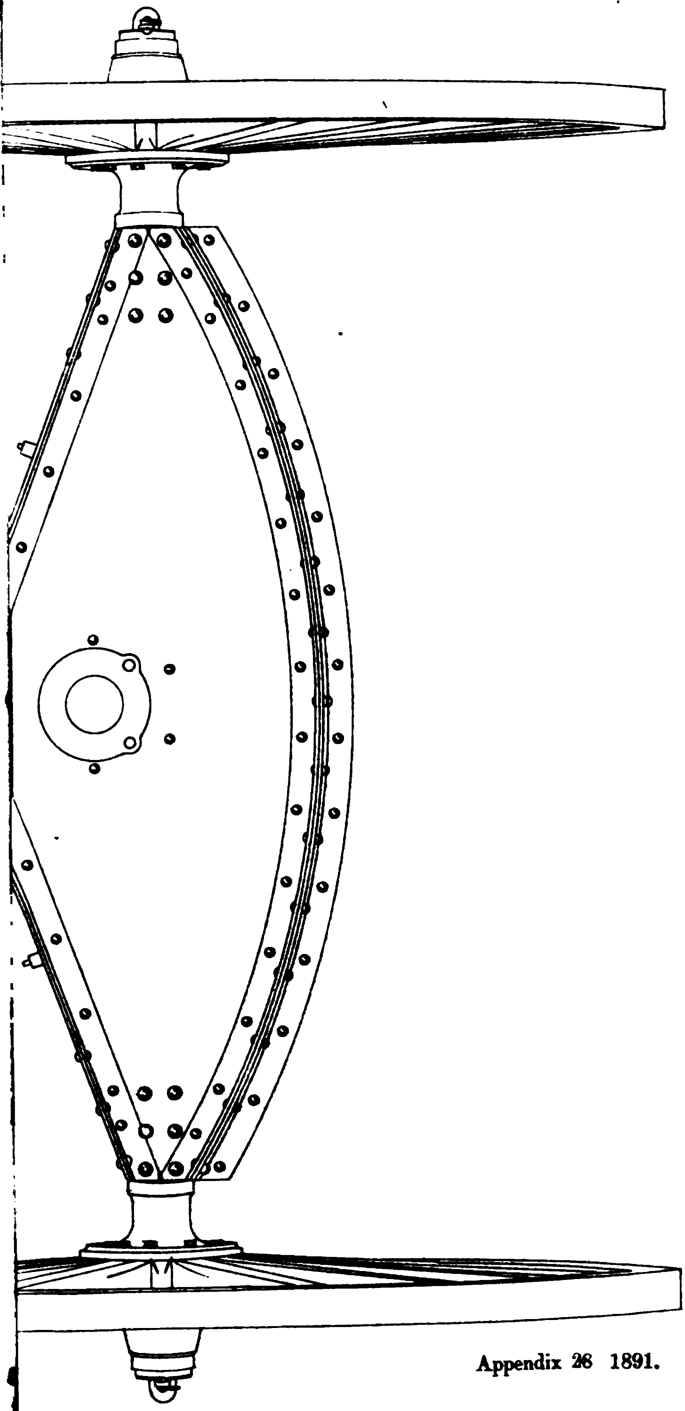
- Body (metal) and connected parts—Continued.
  - Pole, with shoe and neck-yoke stop.
  - Pole key, with safety spring.
  - Doubletree bolt, with stay and stay bolts.
  - Doubletree stay chains.
  - Doubletree, wood, ironed.
  - Singletrees, wood, ironed.
  - Neck-yoke, wood, ironed.
  - Pole pad.
  - Neck-yoke pads.
- Ammunition chest (wood, ironed):
  - Chest.
  - Lid.
  - Hinges.
  - Hasp.
  - Turn-buckle and stud.
  - Corner irons.
  - End irons.
  - Shield.
  - Canvas cover on lid.
  - Paulin straps on lid.
  - Two wooden partitions, dividing interior into three compartments.
  - Copper strips covering hinge and hasp straps.
  - Bolts, nuts, and plates to attach chest to body.

MET



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# APPENDIX 29.

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## *SPECIFICATIONS FOR PREPARING THE SITE AND MAKING THE NECESSARY EXCAVATIONS FOR THE FOUNDATIONS, ETC., AND FOR ERECTING ALL WALLS, PIERS, AND OTHER MASONRY UP TO THE TOP LEVEL OF THE WATER TABLE, FOR THE SOUTH WING OF THE ARMY GUN FACTORY BUILDING AT THE WATERVLIET ARSENAL, WEST TROY, N. Y., AS SHOWN ON THE ACCOMPANYING PLANS AND DRAWINGS.*

### CONDITIONS.

The drawings and specifications are intended to be alike in every respect; but any work shown on the drawings and not particularly described in the specifications, and any work evidently necessary to the completion of the work as specified or shown, is to be done by the contractor without extra charge, the same as if it were shown or specified.

The contractor is to comply with the State or other laws, and is to be liable for all penalties and all damages to life and limb that may occur owing to his negligence, or that of his employés, during the erection of the building. No claim for extra work shall be made unless before the performance of such extra work the commanding officer shall have first authorized, in writing, such extra work; nor unless, before the performance of such extra work, the price to be paid therefor shall likewise first have been agreed upon in a manner as required by law, between the Government and the contractor, and done in obedience to a written order from the commanding officer, given before the performance of such extra work. An exception will be made from this rule only in the case of foundation masonry, the amount of which may be increased, according to the decision of the commanding officer. The bidder will give for this purpose, in addition to his bid for the whole work, the price per cubic yard for which he will furnish such additional excavations and stone or brick masonry.

All necessary detail drawings will be furnished and any work not in conformity with such drawings, or differing from the requirements of the drawings or specifications, or not otherwise approved by the commanding officer, will be rejected and must be removed, remade, and replaced; and all work or material injured or destroyed thereby must be made good at the contractor's expense. The Government reserves the right to annul and cancel the contract in case the contractor neglects or refuses to remove work rejected and to replace the same within three days after having been notified, in strict conformity with the drawings and specifications and according to the instructions of the commanding officer; and in case the contract is so annulled, all materials furnished and the work done in accordance with the drawings or specifications at the time the contract is rescinded is to be paid for at the schedule prices on which the contract price is based, and no claim is to be allowed for any profit on work not completed at the time the contract is canceled. The Government reserves the right to employ other parties to remove, replace, or complete the work, holding the contractor for any difference in cost between the actual cost and the unpaid balance of the contract; *also, for the fixed fines* provided in the contract in case of failure to complete the work within the time specified.

A schedule in detail of the prices on which the contract is based is to be furnished to the Government on signing the contract, which schedule shall be the basis for all payments on account of the contract.

Payments will be made, at the request of the contractor, not oftener than once a month, based on an estimate, made by the commanding officer, of the amount of work done, and of the value thereof, according to the terms of the contract. The first such estimate shall be of the amount or quantity and value of the work done since the contractor commenced the performance of the contract on his part. And every subsequent estimate (except the final one) shall be of the amount or quantity and value of work done since the last preceding estimate was made.

The Government will pay the contractor ninety per cent of such estimated value upon each such estimate being made.

On the expiration of thirty days after the completion of the contract and the acceptance of the whole work, the Government will pay to the contractor the amount remaining after deducting from the contract price the amount or value of all such sums as shall theretofore have been paid to the contractor under any of the provisions of the contract; also, all such sums as shall have been reserved or retained.

All payments made on work during its progress on account of the contract or extra work shall in no case be construed as an acceptance of the work executed; but the contractor shall be liable to all the conditions of the contract until the whole work is finished and completed.

The contractor must have some competent person on the work to receive instructions and see when his particular work is required. Subcontractors will not be recognized.

The Government reserves the right to make any alteration in the plans, forms, construction, detail, or execution described by the drawings or specifications without invalidating or rendering void the contract; and in case of any difference in expense, an addition to or abatement from the said contract amount shall be made in the ratio or proportion such work may bear to the whole contract work agreed to be performed; and the same to be determined as before mentioned.

All work will be under the supervision of the commanding officer and such inspectors as he may designate.

Contractors will be notified in writing of any changes in said positions.

The commanding officer will give on demand such interpretations, either verbally or by writing or drawing, as in his judgment the nature of the work may require, having particular care that any and all work done and material used for the work be such as hereinafter described. He shall also determine the amount of damages which may occur from any cause and decide upon the fitness of all material used and work done.

It is not incumbent upon him to notify the contractor to attend to and have in readiness his own work and the requisite materials at such times as the progress of the building may require them. If the contractor does not attend to his part of the work and have his portion of the materials and work in readiness, as it may be wanted to work into the building, he will be held accountable for all delays and damages in consequence of any such neglect.

The opinion, report, and decision on all matters of the commanding officer will be binding and conclusive.

A railroad track, connecting with the D. & H. Company's track, runs close by the site for the south wing, as shown on Plate I, which will enable the contractor to transport all building material to the site per rail. But the contractor must unload all material as soon as received or else he may put his loaded cars on such sidings and to such extent as may be determined by the commanding officer.

## MATERIALS AND WORKMANSHIP.

All materials of every kind and description must be of the very best quality, and anything necessary to the completion of the work as shown in drawings and as directed by these specifications is to be executed in the most thorough, substantial, neat, and workmanlike manner, to the entire satisfaction of the commanding officer, to whom every facility is to be given by the contractor for inspecting the work as it progresses.

The contractor is to furnish all necessary materials and labor, and is to provide all tools, derricks, hoists, scaffolding, planks, runs, horses, and all mechanical appliances for properly prosecuting the work.

All water necessary for building purposes may be taken from such hydrants or other sources as will be designated by the commanding officer, but the contractor has to make satisfactory arrangements to avoid wasting water by his employés at any time.

Dimensions figured on the drawings are to be followed in all cases in preference to scale measures, and the wording of specifications takes precedence over both.

Where work is not sufficiently and clearly specified, or where the work is not explained by the drawings, accompanied by a detailed description of the sizes of the various parts and the method of their union, the contractor shall, in all cases, before the execution of the work, submit to the commanding officer for his indorsement a detailed specification for the same. He shall be at liberty to alter and amend such specifications if, in his opinion, the work as described is not of materials, proportions, or workmanship best adapted for the purpose.

## GENERAL DESCRIPTION.

The location of the new south wing is shown in Plate No. I of the drawings, as are also its relative distances from adjoining buildings.

It comprises twenty-two bays of the main aisle, the east aisle, and the west aisle.

The total length of the building between water-table lines is 401 feet 9 inches, and the total width is 159 feet.

The main aisle is 75 feet wide in the clear between walls, the east aisle 22 feet, and the west aisle is 52 feet.

The east and west aisles form extensions of the principal structure on both sides for the entire length of same.

The foundations of all exterior walls are built of rubble masonry, laid on concrete; all other walls are built of bricks, laid on concrete.

The arrangement of the building, and all sizes, dimensions, and details are fully shown on drawings. If any discrepancy is discovered in the drawings, or between them and the specifications, the question is to be referred to the commanding officer for settlement.

## ITEM I.

### EXCAVATIONS.

The site to be leveled is inclosed in the plans.

The dimensions of the site to be leveled are given in the plans; also its relative distances from adjoining buildings.

The site is to have a uniform level, which must be 24 inches below the floor line of the gun-factory building throughout. Such points of the site as lie already below the desired level need not be filled up to that level. The excavation is composed of earth and shale, and the estimated amount of such excavation is about 9,780 cubic yards.

About 500 cubic yards of the excavated material is to be deposited at a place marked K on the plan. The remainder of the excavated material is to be deposited at a place marked L on the plan, or at such other points as may be designated at any time, but not to a greater distance from the point of excavation than that of site L. The contractor may remove from the arsenal grounds entirely, if he wishes to do so, as much of the excavated material and under such conditions as will be determined by the commanding officer.

All excavated material which the contractor will deposit on sites K and L must be well distributed, so as to disfigure the ground as little as possible.

Besides leveling the site for the new south wing, trenches and pits will have to be excavated for the foundation walls of the building, etc., as indicated on the plan. The bottom level of all exterior trenches except trench T must not be less than 30 inches below the established level of the site. The bottom of all pits marked O to be 12 inches below the established level of the site. If no solid rock should be found at that depth at any place, the contractor will excavate at such places the trenches and pits to a greater depth until solid rock is found at the bottom. The bottom grade of trenches T and U is figured in drawings.

The bidder can ascertain the relative amount of earth, slate, etc., to be excavated from trenches from personal inspection and such soundings as he may desire to make.

The bottom of all trenches must be horizontal; where differences in the depth occur steps should be made, and no sloping trenches will be allowed. The bottom of all trenches must be free from lumps and should be even. The least width of the bottom of trenches is given by figures in the sketch. Where the excavation will not stand vertically, a slope of 3 inches for every foot in depth will be made.

The contractor to provide narrow ditches to keep the excavations clear of all surface water caused by rain and natural drains of the soil.

As much of the material excavated from the trenches as will be required for refilling trenches after foundation walls have been built (about one-half) will be left all along both sides of trenches, but it must be deposited far enough to prevent any of it from being thrown into the trenches for walls during building operations. The remainder of the excavations from trenches will have to be deposited at the sites marked K and L on the plan.

Contractor to keep out all water that may interfere with his operations, at his own expense.

All work will be subject to the approval of the commanding officer, and he will have the power to reject or condemn any work which, in his opinion, is defective. All excavations will be prepared under his direction and to his satisfaction, and should any misunderstanding arise as to the import of anything contained in these specifications, the explanation of the commanding officer will be binding on the contractor.

| | |
|---|---|
| Approximate excavation for leveling site | 9,050 cubic yards. |
| Approximate excavation for trenches and pits | 730 cubic yards. |
| Total | 9,780 cubic yards. |

All surveying will be done by the contractor at his own expense, except the principal lines and levels, which will be given by the Ordnance Department. Principal lines: A, lines of exterior face of water table; B, face lines of top of interior brick piers; C, center lines of all crane piers. Principal levels: 1, top level of water table; 2, top levels of crane piers and interior brick piers. The work of leveling the site and excavating the trenches must commence simultaneously at the north end and must be carried on simultaneously on southward over the entire width uniformly and vigorously in order to allow the mason work to follow in the same manner.

## ITEM II.

### MASON'S SPECIFICATIONS.

### *1. Refilling and grading.*

After the walls and piers are above ground the trenches, etc., must be refilled and solidly rammed around walls and piers by the contractor for the mason work. He is also to fill and grade the grounds around outside walls for a distance of 15 feet on all sides of the building. All ground lines around building must slope away from walls as shown, and ground must be tightly rammed. The highest points of ground outside of walls will be one foot below the floor line, the lowest point not lower than one foot below highest point.

### *2. Concrete.*

The foundations of all walls and piers will be laid on a bed of concrete at the bottom of the excavations. The depth and all other dimensions of concrete beds are shown in drawings. The concrete shall be formed of sound broken stone, not exceeding two inches at their greatest diameter and of a quality approved by the commanding officer. All stone in any way larger is to be thrown out. The sand to be used must be of a coarse grain, clean and sharp, and free from loam.

The cement must be equal in quality to the best Rosendale cement, and made by manufacturers of established reputation; it must be fresh and very fine ground, and in well made and lined casks. The tensile strength of a specimen twenty-four hours after molding, air-dry, must not be less than 80 pounds per square inch of section. To insure its good quality all the cement furnished by the contractor will be subject to inspection and rigorous tests, and if found of improper quality will be branded and must be immediately removed from the site. The contractor shall at all times keep in store at some convenient point in the vicinity of the work a sufficient quantity of cement to allow ample time for the tests to be made without delay to the work of construction. The commanding officer shall be notified at once of each delivery of cement. It shall be stored in a tight building, and each cask must be raised several inches above the ground by blocking or otherwise.

The materials for concrete to be cleaned from dirt and dust before being used; to be mixed dry in proper boxes in the following proportion: One part by measure of cement to two parts of sand and five parts of broken stone.

The sand will be put into the box first and spread out; the cement will be spread over the sand then, and both will be turned over three times to assure a uniform mixture. The stone, having been well wetted, is next added and all ingredients are turned over twice with shovels, adding a moderate quantity of water to produce a mixture of proper consistency.

The mixing is to be done near the place of laying, the concrete to be laid immediately after mixing into wetted ground and to be thoroughly compacted with heavy tampers till the water flushes to the surface. The concrete shall be allowed to set for about twenty-four hours before any work shall be laid upon it; the time of setting can be reduced only by permission of the commanding officer. No walking over or working upon it shall be allowed while it is setting.

### 3. *Cut stone.*

All cut stone required for the new building is shown on Plate No. 4 of the drawings, and comprises the following:

1. The water table and the door-sills of sizes and shapes as shown on drawings.

Bed and build of this stone to be trued and smoothed with a good point finish; all exposed surfaces (the top of door-sills entirely) to have the same finish as that of the already finished part of the gun factory.

The water table to be furnished in lengths not less than figured in drawings, but contractor may double lengths at his option.

2. Eighty-one cap-stones or piers for columns of crane bridges and building of sizes shown in detail drawings. These stones to be square and to have parallel and true bearings top and bottom (point finish). The top must be smoothly finished; the sides to have rock faces. Four 2-inch holes to be cut in each stone from top to bottom, to figures given in drawing.

All cut stone described is to be of first-class hard blue limestone, or of other hard and suitable stone of approved quality, similar in appearance to that of north wing, free from all defects, and uniform in color. The bidder to submit with his bid a sample or samples of stone, showing texture and the different kinds of finish required, and on which his bid is based.

The stones shall be cut to exact dimensions, and all angles and arrises shall be true, well defined, and sharp. All beds, builds, and joints shall be dressed for the full depth of the stone; all joints to be very close.

The contractor to do all cutting in place which is necessary for the completion of any work on the building.

### *Stone masonry.*

The foundations of all exterior walls of the building below the water table are to be built of rubble masonry.

The stone for this rubble masonry will be furnished by the contractor, and must be of sound limestone from a layer and quarry approved by the commanding officer.

The foundation walls are to be built upon a bed of concrete, as described heretofore. All stone resting direct on the concrete must be imbedded in pure domestic cement of approved quality; the rest of the

the import of anything contained in these specifications, the explanation of the commanding officer will be binding on the contractor.

| | |
|---|---|
| Approximate excavation for leveling site | 9,050 cubic yards. |
| Approximate excavation for trenches and pits | 730 cubic yards. |
| Total | 9,780 cubic yards. |

All surveying will be done by the contractor at his own expense, except the principal lines and levels, which will be given by the Ordnance Department. Principal lines: A, lines of exterior face of water table; B, face lines of top of interior brick piers; C, center lines of all crane piers. Principal levels: 1, top level of water table; 2, top levels of crane piers and interior brick piers. The work of leveling the site and excavating the trenches must commence simultaneously at the north end and must be carried on simultaneously on southward over the entire width uniformly and vigorously in order to allow the mason work to follow in the same manner.

## ITEM II.

### MASON'S SPECIFICATIONS.

### *1. Refilling and grading.*

After the walls and piers are above ground the trenches, etc., must be refilled and solidly rammed around walls and piers by the contractor for the mason work. He is also to fill and grade the grounds around outside walls for a distance of 15 feet on all sides of the building. All ground lines around building must slope away from walls as shown, and ground must be tightly rammed. The highest points of ground outside of walls will be one foot below the floor line, the lowest point not lower than one foot below highest point.

### *2. Concrete.*

The foundations of all walls and piers will be laid on a bed of concrete at the bottom of the excavations. The depth and all other dimensions of concrete beds are shown in drawings. The concrete shall be formed of sound broken stone, not exceeding two inches at their greatest diameter and of a quality approved by the commanding officer. All stone in any way larger is to be thrown out. The sand to be used must be of a coarse grain, clean and sharp, and free from loam.

The cement must be equal in quality to the best Rosendale cement, and made by manufacturers of established reputation; it must be fresh and very fine ground, and in well made and lined casks. The tensile strength of a specimen twenty-four hours after molding, air-dry, must not be less than 80 pounds per square inch of section. To insure its good quality all the cement furnished by the contractor will be subject to inspection and rigorous tests, and if found of improper quality will be branded and must be immediately removed from the site. The contractor shall at all times keep in store at some convenient point in the vicinity of the work a sufficient quantity of cement to allow ample time for the tests to be made without delay to the work of construction. The commanding officer shall be notified at once of each delivery of cement. It shall be stored in a tight building, and each cask must be raised several inches above the ground by blocking or otherwise.

The materials for concrete to be cleaned from dirt and dust before being used; to be mixed dry in proper boxes in the following proportion: One part by measure of cement to two parts of sand and five parts of broken stone.

The sand will be put into the box first and spread out; the cement will be spread over the sand then, and both will be turned over three times to assure a uniform mixture. The stone, having been well wetted, is next added and all ingredients are turned over twice with shovels, adding a moderate quantity of water to produce a mixture of proper consistency.

The mixing is to be done near the place of laying, the concrete to be laid immediately after mixing into wetted ground and to be thoroughly compacted with heavy tampers till the water flushes to the surface. The concrete shall be allowed to set for about twenty-four hours before any work shall be laid upon it; the time of setting can be reduced only by permission of the commanding officer. No walking over or working upon it shall be allowed while it is setting.

### *3. Cut stone.*

All cut stone required for the new building is shown on Plate No. 4 of the drawings, and comprises the following:

1. The water table and the door-sills of sizes and shapes as shown on drawings.

Bed and build of this stone to be trued and smoothed with a good point finish; all exposed surfaces (the top of door-sills entirely) to have the same finish as that of the already finished part of the gun factory.

The water table to be furnished in lengths not less than figured in drawings, but contractor may double lengths at his option.

2. Eighty-one cap-stones or piers for columns of crane bridges and building of sizes shown in detail drawings. These stones to be square and to have parallel and true bearings top and bottom (point finish). The top must be smoothly finished; the sides to have rock faces. Four 2-inch holes to be cut in each stone from top to bottom, to figures given in drawing.

All cut stone described is to be of first-class hard blue limestone, or of other hard and suitable stone of approved quality, similar in appearance to that of north wing, free from all defects, and uniform in color. The bidder to submit with his bid a sample or samples of stone, showing texture and the different kinds of finish required, and on which his bid is based.

The stones shall be cut to exact dimensions, and all angles and arrises shall be true, well defined, and sharp. All beds, builds, and joints shall be dressed for the full depth of the stone; all joints to be very close.

The contractor to do all cutting in place which is necessary for the completion of any work on the building.

### *Stone masonry.*

The foundations of all exterior walls of the building below the water table are to be built of rubble masonry.

The stone for this rubble masonry will be furnished by the contractor, and must be of sound limestone from a layer and quarry approved by the commanding officer.

The foundation walls are to be built upon a bed of concrete, as described heretofore. All stone resting direct on the concrete must be imbedded in pure domestic cement of approved quality; the rest of the rubble masonry to be laid in hydraulic cement mortar; all stone to be laid on its natural bed. All beds and joints must be full of mortar, and no grouting or filling of joints will be allowed after the stones are in place. The work must be thoroughly bonded. For the outside face of walls, at least for a depth of 12 inches below the water table, stones should be selected with exposed faces smooth and clean.

Top and sides of the rubble masonry to be finished perfectly straight, and top to form a uniform horizontal and level bearing throughout for the water table and the brickwork. Joints to be full of mortar, close, and well flushed up. All face joints above ground, and also all joints in water table and in window-sills to be pointed with pure cement, applied before its setting.

All stones to be wetted and all walls underground to be cemented on outside.

Mortar for the rubble masonry shall be prepared from cement of the same quality as specified for concrete—one part, by measure, of cement to two parts of clean, sharp, screened sand.

These ingredients shall be thoroughly mixed dry. A moderate quantity of water is afterward added to produce a paste of proper consistency; the whole to be thoroughly mixed with hoes. In measuring cement, it shall be packed as received from the manufacturer. The mortar shall be freshly mixed, in proper boxes for the work in hand, and no mortar must be used that had become hard or set.

All rubble masonry is to be built to the dimensions shown on the drawings.

It may be necessary to excavate the trenches for foundation walls on some points to a greater depth than shown on drawings.

In all such cases the contractor will build the increased amount of masonry. Therefore, in addition to his bid for the whole work, he will give the price per cubic yard for which he will furnish any masonry in excess of that shown on the plans.

The upper or capstone of each pier for columns of traveling crane must be solidly bedded, with top side dressed square and level to receive columns. The holes for foundation bolts to be in perfect line with axis of building. Foundation bolts will be furnished by the Ordnance Department.

The contractor, at his own expense, must conduct the water away from any point where masonry is being laid, by the use of trenches, pipes, or other efficient means, and must prevent water from flowing over the masonry till it is fully set. Under no circumstances shall masonry be laid in water.

### *Brick masonry.*

Contractor to furnish all brick masonry in walls and piers, as shown on plans.

The brick masonry of all exterior walls to commence on top of the rubble masonry, and of all other walls and piers to commence on a bed of concrete, except where shown otherwise on plans.

All brickwork below the floor line to be laid in best hydraulic cement and rock-lime mortar, mixed in the proportion of one part cement, one-half part lime, and two parts sand, properly mixed, as much at a time as can be used before setting; no cement mortar to be used after it had been once set.

Said cement mortar to be used to a height in level with the floor line of the building, at which point the last course shall be evenly and smoothly pargetted over with cement.

The bricks shall be of best quality of hard-burnt bricks, burnt hard entirely throughout, regular and uniform in shape and size and of compact texture. To insure their good quality, the bricks furnished by the contractor will be subject to inspection and rigorous tests, and if found of improper quality will be condemned; the character of the tests to be determined by the commanding officer.

No bats shall be used without his permission, but nothing smaller than half bricks.

Foundation-bolts and washers to be built into brick piers of crane columns, as shown on detail drawings. They must be placed carefully by means of a templet, and in proper height for the cast-iron base-plates to be screwed down. The space in the pocket around bolts to be cast out with pure cement to top of brickwork.

Bricks must not be dumped, but must be piled at the site at places to be designated. Bricks injured by being driven over will be rejected.

Bids will be received for the whole work comprised in items I and II, combined.

The work must commence soon after the date of the notification by the commanding officer of the award of the contract. It must commence at the north end, and must be pushed uniformly for the whole width of the building, and rigorously, and the whole work must be completed within three months from the time of notification of the award of the contract.

A penalty of $30 will be exacted for each and every day of delay beyond the time for the completion of the whole work.

# APPENDIX 30.

## *SPECIFICATIONS FOR THE DELIVERY AND ERECTION OF THE IRON-WORK FOR THE SOUTH WING OF THE ARMY GUN FACTORY, WATERVLIET ARSENAL, WEST TROY, N. Y., AS PER ACCOMPANYING DRAWINGS.*

### CONDITIONS.

The drawings and specifications are intended to be alike in every respect; but any work shown on the drawings and not particularly described in the specifications, and any work evidently necessary to the completion of the work as specified or shown, is to be done by the contractor without extra charge, the same as if it were shown or specified.

The contractor is to comply with the State or other laws, and is to be liable for all penalties and all damages to life and limb that may occur owing to his negligence or that of his employés during the erection of the building. No claim for extra work shall be made unless before the performance of such extra work the commanding officer shall have first authorized, in writing, such extra work; nor unless before the performance of such extra work, the price to be paid therefor shall likewise first have been agreed upon, in a manner as required by law, between the Government and the contractor, and done in obedience to a written order from the commanding officer, given before the performance of such extra work.

All necessary detail drawings will be furnished, and any work not in conformity with such drawings or differing from the requirements of the drawings or specifications, or not otherwise approved by the commanding officer, will be rejected, and must be removed, remade, and replaced; and all work or material injured or destroyed thereby must be made good at the contractor's expense. The Government reserves the right to annul and cancel the contract in case the contractor neglects or refuses to remove work rejected and to replace the same within three days after having been notified, in strict conformity with the drawings and specifications, and according to the instructions of the commanding officer; and in case the contract is so annulled, all materials furnished and the work done in accordance with the drawings or specifications, at the time the contract is rescinded, is to be paid for at the schedule prices on which the contract price is based, and no claim will be allowed for any profit on work not completed at the time the contract is canceled. The Government reserves the right to employ other parties to remove, replace, or complete the work, holding the contractor for any difference in cost between the actual cost and the unpaid balance of the contract; also for the fixed fines provided in the contract in case of failure to complete the work within the time specified.

A schedule in detail of the prices on which the contract is based is to be furnished to the Government on signing the contract, which schedule shall be the basis for all payments on account of the contract.

Payments will be made at the request of the contractor not oftener than once a month, based on an estimate made by the commanding officer, of the amount of work done and of the value thereof, according to the terms of the contract. The first such estimate shall be of the amount or quantity and value of the work done since the contractor commenced the performance of the contract on his part. And every subsequent estimate, except the final one, shall be of the amount or quantity and value of work done since the last preceding estimate was made.

The Government will pay the contractor 90 per cent of such estimated value upon each such estimate being made.

On the expiration of thirty days after the completion of the contract and the acceptance of the whole work the Government will pay to the contractor the amount remaining after deducting from the contract price the amount or value of all such sums as shall theretofore have been paid to the contractor under any of the provisions of the contract; also all such sums as shall have been reserved or retained.

All payments made on work during its progress on account of the contract or extra work shall in no case be construed as an acceptance of the work executed; but the contractor shall be liable to all the conditions of the contract until the whole work is finished and completed.

The contractor must have some competent person on the work to receive instructions and see when his particular work is required. Subcontractors will not be recognized.

The Government reserves the right to make any alteration in the plans, forms, construction, detail, or execution described by the drawings or specifications, without invalidating or rendering void the contract; and in case of any difference in expense an addition to or abatement from the said contract amount shall be made in the ratio or proportion such work may bear to the whole contract work agreed to be performed, and the same to be determined as before mentioned.

All work will be under the supervision of the commanding officer and such inspectors as he may designate.

Contractors will be notified in writing of any changes in said positions.

The commanding officer will give, on demand, such interpretations, either verbally or by writing or drawing, as in his judgment the nature of the work may require, having particular care that any and all work done, and material used for the work, be such as hereinafter described. He shall also determine the amount of damages which may occur from any cause and decide upon the fitness of all material used and work done.

It is not incumbent upon him to notify the contractor to attend to and have in readiness his own work and the requisite materials at such times as the progress of the building may require them. If the contractor does not attend to his part of the work, and have his portion of the materials and work in readiness as it may be wanted to work into the building, he will be held accountable for all delays and damages in consequence of any such neglect.

The opinion, report, and decision on all matters of the commanding officer will be binding and conclusive.

A railroad track, connecting with the D. & H. Company's track, runs close by the site for the south wing, as shown on Plate 1, which will enable the contractor to transport all building material to the site per rail. But the contractor must unload all material as soon as received, or else he may put his loaded cars on such sidings and to such extent as may be determined by the commanding officer.

## MATERIALS AND WORKMANSHIP.

All materials of every kind and description must be of the very best quality, and anything necessary to the completion of the work, as shown in drawings, and as directed by these specifications, is to be executed in the most thorough, substantial, neat, and workmanlike manner, to the entire satisfaction of the commanding officer, to whom every facility is to be given by the contractor for inspecting the work as it progresses.

The contractor is to furnish all necessary materials and labor, and is to provide all tools, derricks, hoists, scaffolding, planks, runs, horses, and all mechanical appliances for properly prosecuting the work.

All water necessary for building purposes may be taken from such hydrants or other sources as will be designated by the commanding officer, but the contractor has to make satisfactory arrangements to avoid wasting water by his employés at any time.

Dimensions figured on the drawings are to be followed in all cases in preference to scale measures, and the wording of specifications takes precedence over both.

Where work is not sufficiently and clearly specified, or where the work is not explained by the drawings, accompanied by a detailed description of the sizes of the various parts and the method of their union, the contractor shall, in all cases, before the execution of the work, submit to the commanding officer for his indorsement a detailed specification for the same. He shall be at liberty to alter and amend such specifications if, in his opinion, the work as described is not of materials, proportions, or workmanship best adapted for the purpose

## IRONWORK.

The materials to be used in the construction to be of iron, mild steel, etc., as specified, and all the iron and steel to be of domestic manufacture.

All plating, the I-beams, channel-bars, angle and tee-bars to be of wrought-iron or mild steel of a tensile strength and a ductility as hereinafter specified.

All castings to be made of the best quality pig-iron.

All material to be tested will be submitted in lots. All pieces of the same kind, size, shape, and weight per unit comprise one lot.

The contractor will notify the commanding officer whenever one or more lots are ready for inspection, either at his works or at the rolling mill. The commanding officer will send an inspector to that place, who will designate such pieces of each lot as he may desire from which bars for tensile tests, etc., should be cut in the direction of the fiber. Only one test bar is to be taken from each piece. The test bars will be cut out in the presence of the inspector and stamped by him. The tensile tests will be made at the place of inspection, and if facilities for testing do not exist there the bars will be sent for test to this arsenal. All pieces forming the lot will be stamped by the inspector, and if the tests are made at the place of inspection, after satisfactory tests have been obtained, but if the tests should not be made at that place, the pieces will be stamped before the departure of the inspector.

The number of test bars required is as follows:

From each lot, forming 150 pieces, or any fraction thereof, two pieces will be selected for test. The lot will be accepted as to tensile strength and elongation if both tests are satisfactory. If both are unsatisfactory, the lot will be rejected. If one test fails, a third bar may be selected for test, and the result of this third test will decide the acceptance or nonacceptance of the whole lot.

From lots exceeding 150 pieces, two test pieces will be required for every 100 pieces or any fraction of 100. The acceptance of the bars to be determined by the results of the tests in the manner above set forth.

The construction of all structures to be furnished is based on material of a tensile strength of not less than 50,000 pounds per square inch, an elastic limit of not less than 32,000 pounds per square inch, with 23 per cent elongation in 8 inches.

Should the use of wrought iron be directed for any part of the work, the tensile strength in pounds per square inch of test bars of tensile members shall be determined after the formula

$$52{,}000 - \frac{7{,}000 \times \text{area of original bar}}{\text{circumference of original bar}} \text{ (all in inches).}$$

The elongation must be 20 per cent.

All shaped iron must show by the test pieces a tensile strength in pounds per square inch of—

$$50{,}000 - \frac{7{,}000 \times \text{area of original bar}}{\text{circumference of original bar}},$$ with an elongation of not less than 12 per cent.

Of the whole lot of eye-bars three full size eye-bars, with eyes of flat bars and three of round bars, will be submitted for test to destruction.

The eye-bars will be accepted—

1st. If not more than one-third of the bars tested break in the eye; or,

2d. If more than one-third do break in the eye and the average of tests of those which so break shows a tensile strength in pounds per square inch or original bar given by the formula—

$$52{,}000 - \frac{7{,}000 \times \text{area of original bar}}{\text{circumference of original bar}} - 500 \times \text{width of bar (all in inches).}$$

Eye-bars will be sent for test to this arsenal, if the contractor has no facilities to make same at or near his works.

If the contractor desires to test additional and more than three eye-bars, such tests will be made at his expense under the supervision of the Government.

The material must undergo also bending tests whenever required by the inspector. The test bars, which may be similar in size to those for tensile tests, must stand bending over double under the hammer when cold, hot, and when heated to a uniform cherry red and quenched in water.

The tensile tests of bars and shapes alone will not be considered sufficient for their acceptance by the Government, and all tested bars and shapes will be examined either at the contractor's works or when delivered at this arsenal for soundness and smoothness, before being painted.

All built members must be examined before leaving the works of the contractor, and when finished they must be true and free from twists, kinks, buckles, or open joints between component pieces.

All abutting surfaces of compression members, except flanges of plate girders, must be planed or turned, or carefully chipped and filed, if machining is impracticable, to even bearings so that they shall be in such contact throughout as may be obtained by such means. All finished surfaces to be protected with white lead or tallow.

The contractor, before finishing all columns and box-girders for crane bridges, will finish and submit for inspection one column and one box-girder of each kind. The inspector will determine whether workmanship and finish are satisfactory, and if not what has to be done to meet the requirements.

The contractor will notify the commanding officer in due time of any inspection required under the above provisions.

All parts of the metal work will be finally inspected when erected in position in the building, and this inspection will decide about the final acceptance of the work or any part of it by the Government.

The minimum weights and sizes of all metal parts are shown on the plans, and any materials delivered at the buildings which are not of the prescribed weights or sizes will be rejected.

All pin-holes of pin-connected trusses to be very accurately spaced, the distance between outsides of holes in tension members to be $\frac{1}{32}$ less than the figured distance between outsides of finished pins; and the distances between insides of holes in compression members to be $\frac{1}{32}$ inch greater than figured distance between insides of finished pins.

All pin-holes to be drilled on axes of members, and to exceed in diameter those of the finished pins by not more than $\frac{1}{32}$ inch.

Heads of all eye-bars to be formed of dimensions as shown on drawings, and the process of manufacture to be approved by the commanding officer.

Threads of all screw ends to be upset after screwing up nuts, to prevent the latter from working loose.

On one side of splice-plates of girders of crane-bridge must be dilatation holes, of larger diameter than that of bolts (as shown in details). The corresponding holes in web of box-girder to be concentric with the dilatation holes of the splice-plates, and to be drilled and tapped for the connecting bolts. The joints between box-girders are not close, to provide for expansion.

Dilatation holes are provided in all beams and girders, connecting crane columns and girders with the roof of side aisles and walls of building.

The metal of all parts of castings to be uniform and of thickness shown in drawings. The castings must be sound and free from flaws, blow-holes, etc. Surfaces to be true and straight.

Bolt and rivet holes to be drilled or cored; no chipped holes will be allowed. All surfaces must be faced which are designated so on drawings, or in these specifications, or necessarily to be faced to make the construction perfect and complete.

All surfaces of castings bearing on stones must be planed. Top of base-plates of columns of crane-bridge and columns supporting roof in west aisle to be also planed true and parallel with bottom surface. These plates must be uniform in thickness, and must be carefully bedded.

All surfaces of contact between metals not designated to be faced must be even and properly chipped. In all cases the bearings must be full and true.

All columns must be set plumb on true beds.

All girders and beams to be set level, except otherwise directed.

Rails for traveling cranes to be of rolled steel; their shape and connection with girder-boxes are shown on drawings.

All rails must be perfectly straight, top and sides of their thread must be planed true to gauge, and the rails when in place must be in perfect alignment and their top must have a uniform and true level from end to end of craneways. Packing under the rails must be avoided, and any packing required for leveling the runways must be done in the joints of top of columns with girders, or in the joints of base of columns with base plates. The distance from center to center of rails of the runways forming the supports for the same crane must be correct throughout, and the greatest variation permissible at any one place must not exceed $\frac{1}{16}$ of one inch. In order to provide for this, the contractor for the ironwork must himself verify the position of all cast-iron shoes set and built into walls by the contractor for the mason work, and any cutting or packing on braces or girders necessary to obtain the correct conditions must be done by the contractor for the ironwork without extra compensation. All cast-iron shoes built into walls will be hoisted in place and set by the contractor for the mason work, but the cast-iron shoes for the roof-trusses of main roof and the base-plates for all iron columns of crane-bridges, etc., will be put in place by the contractor for the iron work. All anchors for cast-iron shoes in walls must be furnished; only the foundation bolts for the base-plates of columns will be furnished by the Ordnance Department.

All brace-rods to be of "Burden" H. B. & S. iron.

Rivets to be of best quality.

The diameter of rivets must not be more than $\frac{1}{16}$ inch smaller than the hole they are to fill.

Rivets to be heated to a uniform light-red heat before driving. No drift-pins must be used; holes to be reamed out till true.

All rivets, when driven, must completely fill the holes and have full heads, well formed. Sizes of rivets are given in the drawings.

Bolts to be furnished wherever shown in the drawings or called for in these specifications, or otherwise necessary for the completion of the work. Washers under all nuts, and under heads where necessary.

All iron parts to receive one coat of good mineral paint in pure linseed oil after inspection before leaving the shop, and, in addition, all parts inaccessible to painting shall receive a coat of paint before being assembled together.

After erection and approval they shall receive a final heavy coat of the above paint, except the ironwork or skylights, which shall receive two coats.

Contractor to erect all false work, scaffolding, derricks, hoists, etc., necessary for the prosecution of his work, and he assumes all liability in case of accident to men or material.

The workmanship on all material must be first class in every detail, and any work objected to must be made satisfactory.

The contractor is to furnish, erect in place, and finish the following:

1. Twenty-two (22) trusses for main roof, with sliding and stationary shoes and all other castings, as shown on drawings, each truss to have riveted to it thirty-four cast-iron angles for the reception of wooden purlins, as shown. Two $\frac{5}{8}$-inch screw bolts, of ample length to fasten 4 by 8 inch wooden purlins to such angles, must be furnished to each angle. Washers under each bolt-head.

2. Ten (10) iron skylights on roof of west aisle, as shown in drawings and details; all to be complete, except glass and felt. Contractor to put all ironwork in roofs, stated in items 1 and 2, in place, and to put on all wind bracing as shown. Everything must be completely finished for the carpenter to put on purlins and roofing.

3. The ironwork for the roof of east aisle. There are twenty-three trusses, their construction being combined of wood and iron. These trusses are connected with the columns of the eastern runway of travel-

ing crane in main aisle by girders formed of two I-beams, while the upper braces connect the box-girders with the upper rafter-shoe.

4. The ironwork for the roof of west aisle. There are also twenty-three trusses of a combined construction of wood and iron. Each truss has an iron column forming a middle support for girders and rafters. These columns and trusses are connected to walls and to the columns of the western runway of traveling crane in main aisle by girders made of two I-beams. The upper I-braces connect the box-girders of crane runway with the upper rafter-shoe. All base plates for columns to be furnished. Fourteen of these are double for crane and roof-columns, and nine single for roof-columns only. All bolts and washers for connecting wooden parts of roof-trusses (specified in items 3 and 4) to iron parts or with each other, as shown on drawings, must be furnished by the contractor for the ironwork.

All cast-iron shoes, anchors, and plates resting in walls of building must be furnished at the proper time to avoid delay in the construction of the walls of the building. Except these castings the contractor is to hoist all ironwork in place and to assemble and finish the construction.

5. All ironwork for the two runways for traveling crane in main aisle complete, assembled, finished, and erected.

There are 51 base-plates for columns of runways (7 of which are to be in existing central section), 51 columns (7 of which in central section), and 50 girders (6 of which in central section). All connections to be made as shown in drawings, top rails of runways and girders to break joints.

The 7 columns and 6 girders located in existing central section must be connected to columns and girders of existing runway and to walls of building by cutting the present I-braces and making connections as shown in drawings.

All work in connection with the erection of that part of the eastern crane runway which extends into central section will be done at last, after runways in south wing have been completely erected.

6. All ironwork for the two crane runways in west aisle, completely erected, assembled, and finished with all bracing to roof columns and wall of building, as shown on drawings. There are 14 columns resting on common base-plates with roof columns, and 14 columns resting on separate base-plates. All base-plates to be furnished. The runways have 26 girders with top rails, all as shown in drawings. Girders and rails to break joints.

7. Two flights of iron stairs leading to the top of girder-braces in existing central section near west wall, with all necessary ironwork to complete landings, all as per drawings, complete and erected in place. A railing of 1½-inch pipe is to be made on stairs and landings where indicated on drawings.

The ironwork must be erected during the construction of the building in such a manner as not to delay the work of other contractors.

All ironwork must be finished and delivered at the site of the building by the time the walls are up (probably the 15th of November, 1891), and must be erected in place and completely finished within three months after the completion of the masonry work, except such parts as enter into the walls of the building, which must be delivered when required, so as not to delay the progress of any work thereon.

Bidders will make a bid for the ironwork delivered and completely erected in the building.

A penalty of $50 will be exacted for each and every day of delay beyond the time specified in the contract for the completion of the whole work.

# APPENDIX 31.

## *SPECIFICATIONS FOR THE ERECTION AND COMPLETION OF THE SUPERSTRUCTURE OF THE SOUTH WING OF THE GUN FACTORY BUILDING SITUATED AT THE WATERVLIET ARSENAL, WEST TROY, N. Y., AT A PLACE MARKED ON THE ACCOMPANYING MAP, SHEET NO. 1, AND ACCORDING TO THE ACCOMPANYING PLANS AND DRAWINGS.*

### CONDITIONS.

The drawings and specifications are intended to be alike in every respect; but any work shown on the drawings and not particularly described in the specifications, and any work evidently necessary to the completion of the work, as specified or shown, is to be done by the contractor without extra charge, the same as if it were shown or specified.

The contractor is to comply with the State or other laws, and is to be liable for all penalties and all damages to life and limb that may occur, owing to his negligence or that of his employés, during the erection of the building. No claim for extra work shall be made unless before the performance of such extra work the commanding officer shall have first authorized, in writing, such extra work; nor unless, before the performance of such extra work, the price to be paid therefor shall likewise first have been agreed upon, in a manner as required by law, between the Government and the contractor, and done in obedience to a written order from the commanding officer, given before the performance of such extra work. The bidder will give, in addition to his bid for the whole work, the price for which he will furnish brick masonry.

All necessary detail drawings will be furnished, and any work not in conformity with such drawings or differing from the requirements of the drawings or specifications, or not otherwise approved by the commanding officer, will be rejected, and must be removed, remade, and replaced; and all work or material injured or destroyed thereby must be made good at the contractor's expense. The Government reserves the right to annul and cancel the contract in case the contractor neglects or refuses to remove work rejected and to replace the same within three days after having been notified, in strict conformity with the drawings and specifications, and according to the instructions of the commanding officer; and in case the contract is so annulled, all materials furnished and the work done in accordance with the drawings or specifications, at the time the contract is rescinded, is to be paid for at the schedule prices on which the contract price is based, and no claim is to be allowed for any profit on work not completed at the time the contract is canceled. The Government reserves the right to employ other parties to remove, replace, or complete the work, holding the contractor for any difference in cost between the actual cost and the unpaid balance of the contract; *also for the fixed fines* provided in the contract in case of failure to complete the work within the time specified.

A schedule in detail of the prices on which the contract is based is to be furnished to the Government on signing the contract, which schedule shall be the basis for all payments on account of the contract.

Payments will be made, at the request of the contractor, not oftener than once a month, based on an estimate made by the commanding officer of the amount of work done and of the value thereof, according to the terms of the contract. The first such estimate shall be of the amount or quantity and value of the work done since the contractor commenced the performance of the contract on his part. And every subsequent estimate, except the final one, shall be of the amount or quantity and value of work done since the last preceding estimate was made.

The Government will pay the contractor 90 per cent of such estimated value upon each such estimate being made.

On the expiration of thirty days after the completion of the contract and the acceptance of the whole work the Government will pay to the contractor the amount remaining after deducting from the contract price the amount or value of all such sums as shall theretofore have been paid to the contractor under any of the provisions of the contract; also all such sums as shall have been reserved or retained, except as to slating and copper work, for which such retained sums will not be paid before the expiration of one year after the completion of such work, provided it has given satisfactory proof of its good condition during and up to that time.

All payments made on work during its progress on account of the contract or extra work shall in no case be construed as an acceptance of the work executed; but the contractor shall be liable to all the conditions of the contract until the whole work is finished and completed.

The contractor must have some competent person on the work to receive instructions and see when his particular work is required. Subcontractors will not be recognized.

The Government reserves the right to make any alteration in the plans, forms, construction, detail, or execution described by the drawings or specifications without invalidating or rendering void the contract; and in case of any difference in expense, an addition to or abatement from the said contract amount shall be made in the ratio or proportion such work may bear to the whole contract work agreed to be performed; and the same to be determined as before mentioned.

All work will be under the supervision of the commanding officer and such inspectors as he may designate.

Contractors will be notified in writing of any changes in said positions.

The commanding officer will give, on demand, such interpretations, either verbally or by writing or drawing, as in his judgment the nature of the work may require, having particular care that any and all work done and material used for the work be such as hereinafter described. He shall also determine the amount of damages which may occur from any cause, and decide upon the fitness of all material used and work done.

It is not incumbent upon him to notify the contractor to attend to and have in readiness his own work and the requisite materials at such times as the progress of the building may require them. If the contractor does not attend to his part of the work and have his portion of the materials and work in readiness, as it may be wanted to work into the building, he will be held accountable for all delays and damages in consequence of any such neglect.

The opinion, report, and decision on all matters of the commanding officer will be binding and conclusive.

A railroad track, connecting with the D. and H. Company's track, runs close by the site for the south wing, as shown on Plate 1, which will enable the contractor to transport all building material to the site per rail. But the contractor must unload all material as soon as received, or else he may put his loaded cars on such sidings and to such extent as may be determined by the commanding officer.

## MATERIALS AND WORKMANSHIP.

All materials of every kind and description must be of the very best quality, and anything necessary to the completion of the work, as shown in drawings and as directed by these specifications, is to be executed in the most thorough, substantial, neat, and workmanlike manner, to the entire satisfaction of the commanding officer, to whom every facility is to be given by the contractor for inspecting the work as it progresses.

The contractor is to furnish all necessary materials and labor, and is to provide all tools, derricks, hoists, scaffolding, planks, runs, horses, and all mechanical appliances for properly prosecuting the work.

All water necessary for building purposes may be taken from such hydrants or other sources as will be designated by the commanding officer, but the contractor has to make satisfactory arrangements to avoid wasting water by his employés at any time.

Dimensions figured on the drawings are to be followed in all cases in preference to scale measures, and the wording of specifications takes precedence over both.

Where work is not sufficiently and clearly specified, or where the work is not explained by the drawings, accompanied by a detailed description of the sizes of the various parts and the method of their union, the contractor shall, in all cases, before the execution of the work, submit to the commanding officer for his indorsement a detailed specification for the same. He shall be at liberty to alter and amend such specifications if, in his opinion, the work as described is not of materials, proportions, or workmanship best adapted for the purpose.

## GENERAL DESCRIPTION.

The location of the new south wing is shown in Plate No. 1 of the drawings, as are also its relative distances from adjoining buildings.

It comprises: Twenty-two bays of the main aisle; the east aisle, and the west aisle.

The total length of the building between water-table lines is 401 feet 9 inches, and the total width is 159 feet.

The main aisle is 75 feet wide in the clear between walls, the east aisle 22 feet, and the west aisle 52 feet.

The east and west aisles form extensions of the principal structure on both sides for the entire length of same.

The arrangement of the building and all sizes, dimensions, and details are fully shown on drawings. If any discrepancy is discovered in the drawings or between them and the specifications, the question is to be referred to the commanding officer for settlement.

## CUT STONE IN SUPERSTRUCTURE.

All cut stone required above the water-table of the new building is shown on sheets Nos. 5, 10, 28, 29, and 30 of the accompanying drawings, and comprises the following:

1. All window-sills, coping-stones, and string-stones of sizes and shapes as shown on drawings.

Bed and build of this stone to be trued and smoothed with a good point-finish; all exposed surfaces (the top of window-sills entirely) to have a finish of same character as that of the finished part of the gun factory.

The coping-stones to be furnished in convenient lengths, but nothing shorter than 6 feet. The raking coping of present south wall is to be used for the new south wall, but caps of corner pilasters must be new. Any deficiency in length of said raking coping is to be supplied by the contractor without extra compensation; he will also do all necessary cutting due to such transfer.

All window-sills exceeding 6 feet in length must be made in two pieces. A groove, for the reception of a wrought-iron clamp, will be cut in the joint faces of the two stones forming one sill, with sinkings in the top surfaces for letting in the turned-down extremities of the clamps, as shown in detail. The clamps will be furnished by the contractor, who has to put them in place, and to lead them into the stone. The clamps must not come up to the top of sill, and the sinkings must be finished off with neat cement, level with top of sills, to conceal the clamps and make the joint water-tight.

All joints of window-sills and coping must be very close.

String-stones, in level with lower window-sills, are in all corner pilasters of the building. All as shown in drawings.

Exposed faces of coping-stones are to have a finish corresponding to that on the existing building; bed and interior edge to have a good point finish. The coping of all walls running north and south to have a sawed recess (raglet) on top throughout its length and not less than one inch deep, to receive the apron of the copper flashing at eaves; also holes to be cut in every 6 feet for the reception of iron braces; a groove to be cut on exposed part of bottom of all horizontal coping for the entire length of such coping. All the above to be done as shown on detail drawings. Inasmuch as the recesses will have to correspond with the construction of the snow fender they will have to be cut in place. There must be lead plugs in all joints of horizontal copings, and hooked iron braces (completely recessed) in all joints of raking copings. Braces to be made of 2½ by ½ inch flat iron, and to be furnished and leaded in by the contractor for the cut-stone work. He will also provide the lead plugs, while the flashing aprons and the braces forming snow fenders will be leaded in by the contractor for the copper work and snow guards. Holes of 2 inches diameter to be cut every 6 feet through raking coping, to suit and receive upper ends of anchor-bolts of roof.

2. Forty-four stone blocks for the reception of the iron shoes of roof-trusses. Top, bottom, and one small side square, parallel and true, and dressed with a pean hammer, cross-cut or four-cut; all other faces to be rough dressed. Such recesses or holes as are shown in drawings to be cut in these stone blocks.

3. Eight hinge-blocks of sizes and shapes shown in drawings, and to be neatly dressed all over. Contractor to cut recesses for hinge-eyes into blocks (making allowance for slight variation in hinge-eyes). Contractor to apply for a pattern of hinge-eyes and all other anchors, straps, or clamps, which, in compliance with the foregoing, are to be recessed into stone-work.

All cut stone described in items 1 to 3, inclusive, is to be of first-class hard blue stone, or of other hard and suitable stone of approved quality, similar in appearance to that of north wing, free from all defects, and uniform in color. The bidder to submit with his bid a sample or samples of stone, showing texture and the different kinds of finish required, on which his bid is based.

The stones shall be cut to exact dimensions, and all angles and arrises shall be true, well defined, and sharp. All beds, builds, and joints shall be dressed for the full depth of the stone; all joints to be very close.

The contractor to do all cutting in place which is necessary for the completion of any work on the building without extra compensation.

All stone to lie on its natural bed.

### STONE AND BRICK MASONRY.

All stone and brick masonry of the building below the top level of water-table will be furnished under a previous contract. But any masonry in walls and piers above the above level, as shown on plans, will be furnished under this contract. The contractor has to hoist in place and set all cut stone required in the construction of the building. Eight hinge-blocks, recessed for wrought iron hinge-eyes of dimensions shown in drawings, to be built into walls for the main entrance in south wall. The hinge-eyes will be furnished by the contractor. They must be properly set and leaded into stone. All stone blocks for roof-trusses to be properly set and leveled and solidly anchored to walls. All walls and pilasters to be capped with stone of sizes and dimensions shown on drawings, laid with close joints, and pointed with pure cement. Raking coping of present south wall to be taken up and transferred to new south wall, and any cutting on said coping in consequence of such transfer will be done by the contractor, who will also supply any deficiency in its length.

All cut stone work to be well bedded in pure domestic cement of approved quality, and to be anchored to walls wherever shown on drawings. The contractor is to hoist in place and build into walls all anchors, straps, or clamps as shown or specified. Such anchors, etc., will be furnished by the contractor or by other contractors, as specified.

The brick masonry of all walls and piers to commence at the top level of the water-table.

Bricks must not be dumped, but must be piled at the site, at places to be designated. Bricks injured by being driven over will be rejected.

All brick walls and piers must be built perfectly plumb for the entire height, and the contractor must take proper means to insure this. The distance between opposite walls, as shown on drawings, must be maintained from bottom to top.

The junction between south end of present building and north end of new building must be built in all respects so as to conform in appearance to the junction between central section and north wing of present building, and to be in accordance with detail drawings to be furnished by the Ordnance Department.

The contractor is to take down the present south wall, between east and west walls, after the roof of the new building has been completed and all door and window sashes have been inserted. This work is to be done with the greatest care, in order to avoid injury to men or material. The brick and stone must be cleaned off by the contractor and piled up outside the building at a place to be designated by the commanding officer. The window and door frames must be carefully preserved. The two end piers of said wall at junction of east and west walls will be finished off as directed. All other portions of the wall will be removed down to the ground line.

The bricks shall be of best quality hard-burnt bricks, burnt hard entirely throughout, regular and uniform in shape and size, and of compact texture. To insure their good quality, the bricks furnished by the contractor will be subject to inspection and rigorous tests, and if found of improper quality will be condemned; the character of the tests to be determined by the commanding officer.

No bats shall be used without his permission, but nothing smaller than half bricks.

All brick work to be laid in mortar made of domestic cement of approved quality, best hydraulic rock-lime, and clean, sharp sand of coarse grain, in the following proportion: One part of cement to one-half part of lime and two parts ot sand. The mortar to be well and thoroughly mixed. No air-slaked lime to be used. The bricks thoroughly wet just before laying, but drowning must be carefully avoided. Every brick to be completely imbedded in mortar. Care shall be taken to have every joint full of mortar. Competent mechanics shall be employed for this work. All bricks shall be laid close, straight, and plumb, well flushed in and properly bonded, with one course of headers to every six courses in height. Facing bricks to be uniform in color, and all joints on exterior of walls to be neatly pointed with black mortar. Joints in arch work not to exceed ¼ inch.

Brick arches to be turned over all doors, windows, and other openings, as shown on plans. All arches to be triple arches, 12 inches high.

All brick arches must be built upon well-made substantial centers, which must be supported by means of strong uprights from the window-sills, or other points offering unyielding support, in at least three places (at both ends and in the center). Whatever portion of a brick arch rests on top of a window or door frame must be built on a sand center. Centers must remain in place at least four weeks after the completion of arches, and even after that time must not be removed without permit. All centers must coincide as to shape and relative height with the window-frames, and must be most carefully set and leveled before laying any work on them. The contractor for the carpenter work will furnish and put in place all centers, but the contractor for the mason work will verify for himself their strength, position, and level before building on them. The arches must be properly bonded, as directed. Contractor is to hoist in place and build into wall all I-beams to go into five window and door openings of south wall, as shown on plan. These beams to be furnished by the Department.

One wrought-iron anchor 4 by 1 inch to be laid into south wall of building above arches of upper tier of windows. Said anchors to reach across the entire width of the wall, and are to be continued into side walls for a length of not less than 20 feet. The joints in the long piece must be made with splice plates on top and bottom of same material as anchor, and the total area of splice bolts on each end must equal the cross section of the anchor. At junction of main anchor and returns and at rear ends of returns must be heavy welded eyes and bolts of 2 inches diameter and 4 feet length.

All gable walls to be anchored to purlins of roof at intervals of 6 feet, by 2 by ½ inch anchors and 1¼-inch bolts built into middle of walls. The bolts to have sufficient length to reach into holes of the raking coping, those for main wall to be at least 5 feet long. Said anchors to be furnished by the contractor.

All cornices are of brick work, and to be built as shown in elevations and in details.

There are belt courses of cut stone in level with lower window-sills along south front of main aisle and in all corner pilasters of building.

Brick cornice to be well bonded, neatly built and pointed up, and to project 10¾ inches from face of pilasters on main walls of south wing, and 5 inches on walls of east and west aisles. The mortar for the cornice must be freshly mixed to insure its best qualities.

All walls projecting above roof to be cemented with neat cement from under side of capstone to top of flashing. Same to be made waterproof.

Contractor to set and anchor all cast-iron shoes for roof-trusses, girders, beams, and braces wherever shown, and bed them properly in cement. They must be level and firmly secured. All openings in walls in connection with such castings to be made as shown.

All walls at the back of the cornice and top of walls to receive a thick coat of best Portland cement, as shown in detail. If at any time a greater proportion of cement is required in the mortar, it will be furnished by the Ordnance Department.

The contractor to cut out or build up after carpenters, roofers, plumbers, or other contractors everything necessary to complete the building, without extra compensation.

The contractor for the carpenter work will furnish all necessary arch centers, and perform any other carpenter work that may come in his line.

The contractor is to clear the building and site from all refuse and rubbish, to do all refilling and grading about the walls, and to leave in neat condition the grounds occupied by him. He is to give all facilities to other contractors for performing work adjoining his own, and any difference which may arise between two contractors in regard to their adjoining work is to be adjusted by the commanding officer. His decision is to be final in the matter.

The mason work must commence immediately upon the completion of the foundation walls, and is to be prosecuted uniformly and steadily, and no part of any wall shall at any time rise more than 5 feet above the rest. All unfinished work must be raked back, as may be directed by the commanding officer in each case; and before new work is joined to its surface the bricks must be scraped clean, scrubbed with a stiff brush, and well moistened.

The contractor is to set into walls all other anchors, etc., that may be found necessary in the erection and completion of the building and not specified herein, if directed to do so by the commanding officer.

All walls should be finished for the reception of roofs on or before the 1st December, 1891.

All interior surfaces of walls above floor line to receive two heavy coats of whitewash after the building is under roof. Such whitewash must be prepared with a proper amount of glue.

All principal lines and levels will be given by the Ordnance Department; all other surveying will be done by the contractor.

Principal lines:
- A. Face lines of pilasters and of exterior walls;
- B. Face lines of interior brick piers;
- C. Center lines of all brick piers;
- D. Center lines of all cast-iron shoes in level of eaves of building.

Principal levels:
- Levels for all cast-iron shoes at eaves of building, or for iron shoes in brick piers at the height of lower eaves.

## CARPENTER WORK.

The carpenter work comprises mainly the following items:

1. The carpenter work on roofs of main aisle.
2. The carpenter work on roofs of east and west aisles.
3. All doors and windows, as shown in plans, sections, elevations, and details, or otherwise specified.

All framing lumber, as purlins, joists, etc., to be of good quality, mill-sawed, square-edged, straight, sound, dry yellow or white pine lumber, free from loose knots, rot, or any imperfections that will impair its usefulness or strength. All purlins of main roof to be laid on iron trusses, spaced as shown on drawings, and fastened to iron angles by two ⅝-inch screw bolts, or otherwise if so directed.

All purlins which form one string to be scarfed together above iron rafters. Scarfs up and down not less than 8 inches long, and bolted together with two ⅝-inch screw bolts passing through the angle. Washers under all bolt heads and nuts. Screw bolts and washers to be furnished by the contractor for the iron work.

Purlins at north and south walls to extend 4 inches into said walls, and to be anchored to same every 6 feet by wrought-iron anchors 2 by ½ inch. Anchors to be spiked to purlins with three ⅜-inch wrought-iron spikes 3 inches long.

All purlins to be 4 by 8 inches and to reach over two bays; care to be taken to break joints in the direction of the slope of the roof.

The roof-trusses of east and west aisles to the number of 46 (23 in each aisle) are shown on drawings in detail. The main rafters to be 5 by 15 inches. The posts and horizontal braces are of oak lumber. All connections to be made as shown.

Screw bolts and cast-iron washers for connecting posts, braces, and rafters will be furnished by the contractor for the carpenter work. All other bolts in connection with cast-iron shoes, etc., will be furnished by the contractor for the iron work. Purlins to be spaced as shown on drawing and to be notched into rafters. Each purlin to be well nailed to rafter; all purlins forming one string to be spliced. Splices to be above trusses, to be 6 inches long, and to have one ⅝-inch screw bolt going through both pieces; washers to be under heads and nuts. These bolts and washers to be furnished by the contractor for the carpenter work. He is also to furnish three wrought-iron angles for each truss. Angles and their location are shown in detail. Each angle is spiked with two ¼-inch nails to rafter, and with two nails of same size to the purlin against which it lies. Nails to be not less than 3 inches long.

Where purlins terminate at walls they must be securely anchored to walls every 6 feet; anchors to be furnished by the contractor. All roofs to be covered with sound 1¼-inch white pine boards, tongued and grooved, averaging 8 to 10 inches in width, driven up close, and nailed to each purlin through each edge and center. Said roofing to be dressed on one side to a uniform thickness before being laid.

Roof-boards to finish at eaves, as shown on detail drawing. Care must be taken not to injure the cement at top of walls and not to push out coping stones.

All framing on and around skylights to be done as shown in detail drawings. All roofs to be ready for the slater and tinner as fast as iron trusses of main roof are erected.

Ridge boards 8 by 1¼ inches to be on ridges of all roofs. Ridge of main roof to receive also a ridge piece with rounded top for the reception of ridge roll,

### WINDOW FRAMES AND SASHES.

All window frames throughout the entire building to be made as shown on detailed drawings. All exposed woodwork to be made of sound, seasoned, kiln-dried yellow or white pine lumber or of oak where designated, neatly dressed.

Sashes to be sliding or swinging where shown on drawings; all other sashes to be stationary. Sashes to be of heart white pine of dimensions shown. Check-rails to be plowed and bored for cords. All glass to be single and of good quality; sizes are given in drawings.

All sliding sashes to be double hung with 2¼-inch Excelsior axle-pulleys or equal, and Silver Lake sash-cord No. 8, and to be properly balanced with lead or iron weights.

All swinging windows to have stout swivels, fastened on inside of sash, about 4 inches above its middle; also proper arrangements for holding windows open and closed, similar to those in the present building, and galvanized iron flashings on outside of bottom rail to drain off the water.

All window frames to be provided with iron fasteners, to be built into brickwork, as shown on plans.

All window frames to be ready and to be set in place by the contractor as soon as the window sills are set, so as not to cause any delay in the erection of the brick walls.

All window sashes in present south wall to be used for new south wall.

### DOORS.

All door frames and doors to be of size and to be made of such lumber as shown on drawings. All exposed woodwork to be of sound, clear, well seasoned, dry, yellow or white pine or oak lumber. Wooden door frames to be well anchored to brickwork with light iron anchors 2 feet apart (three or four to each jamb). Ends to be doweled to stone sills.

All doors to have stout bolts top and bottom, square spring pattern, appropriate to size and kind of door. Patterns and sizes to be approved by the commanding officer. All doors to be hinged with heavy wrought-iron hook-and-eye hinges. Hinges to reach clear across doors, and for the larger door in south wall to be of 4 by ½ inch iron, and to be fastened with ⅝-inch carriage bolts not more than 8 inches centers. Four such hinges to each wing. All double doors to have stout bolts, square spring pattern, for stationary half.

All doors to have rim locks with triplicate keys, and stout wrought-iron handles and latches on both sides, all of approved sizes, quality, and pattern. All door frames must be set in place by the contractor in time for the mason to build them into brickwork. All doors and windows must be complete in every respect. All window and door frames and sashes to be primed with a coat of white oil paint (white lead in linseed oil) before being delivered on the premises. Door sashes of present south wall to be used in new south wall.

The contractor for the carpenter work to furnish all screw bolts, screws, anchors, spikes, nails, etc., required for the execution of his contract, except where otherwise specified. He is to furnish also all necessary centers for arched openings, and perform any other carpenter work that may come in his line.

### PAINTING.

All window frames and sashes, also door frames and doors, must be painted on the inside and outside with two coats of dark-red paint made up with linseed oil. Color to be same as the present building.

### ROOFING, COPPER WORK, SKYLIGHTS, LIGHTNING RODS, SNOW GUARDS.

All roofs to be covered with No. 1 Chapman slates, or equal, size 10 by 18 inches. Slates to be strong and heavy, and to be laid about 7 inches to the weather, in even tiers with slate on present roof.

Bidder to furnish a sample slate on which his bid is based.

All slates to be nailed on with two 4d. copper flat-head slate nails to each slate. The ridges to have a galvanized iron (No. 24) ridge roll. Roll to be 4 inches, with an 8-inch apron on each side, which is turned down over edges of ridge board, as shown in detail, and securely nailed to said edges.

All valleys to be copper, not less than 20 inches wide. Top course of slate on all ridges and 1 foot on each side of all valleys to be laid in oil cement. All flashings about walls projecting above roof to be of 16-ounce copper. All flashings about walls, etc., to be counterflashed and cemented into joints of brickwork.

Roof at eaves to be covered with 16-ounce copper, as per detailed drawings.

Flashings about skylights to be made, as shown in detail, of 16-ounce copper.

Contractor to furnish wrought-iron galvanized anchors, to anchor horizontal copings to roof. Such anchors to be of sizes and shapes as shown in detail; one end to be hooked, and to be let into recesses of coping-stones at least 1½ inches deep, and to be properly leaded into same. The other end to pass into roof, and to be fastened to purlin by one ½-inch lag-screw and one ⅜-inch wrought-iron spike, as shown in detail. Anchors to be made perfectly water-tight where passing through roof. Main roof to be provided with snow guards, as shown in drawing. The wrought-iron standards of said guards to be 6 feet apart on roof, and to be made in one piece with the aforesaid anchors, and to be galvanized.

The top rail is made of 1¼-inch wrought-iron pipe, in suitable lengths, and left loose in braces for expansion. All braces and everything belonging to snow guards to be properly painted red.

A lightning rod is to be placed on ridge of main roof. Said lightning rod to pass over entire length of ridge, and is to be a copper cable-wire rod, ½ inch, 7 strands, well fastened up. Points and tips to be arranged at south wall of main roof and at intermediate points, 100 feet apart.

Lightning rods to lead to ground at two places (from south end and one intermediate point of main roof) and to terminate in copper plates put underground 5 feet below the surface.

Fastenings on roof and walls to be insulated.

The contractor is to furnish and put into place all skylight glass, ¼ inch thick, ribbed. Said glass to be 18 by 54 inches, except two courses in each skylight, where the glass is only 15 inches wide. The glass is to be put in place and to be made perfectly water-tight with felt soaked in oil, as shown in detail drawing. Contractor to furnish and secure proper copper flashings, and make skylights complete and water-tight.

All roofs to be covered with 3-ply ready roofing (laid to lap at least 2 inches), well tacked down before laying on slates.

The contractor is to put under all copper one thickness of the heaviest red rosin-sized paper before laying copper.

All copper to be used to be 16-ounce sheet copper, well nailed down and soldered heavy with the best solder.

The work at eaves to be made as shown in detail, and the apron is to be let into a recess on top of coping-stone throughout and to be well leaded in.

The junction of present and of new roof must be made so as to produce a uniform surface without interruption.

On completion of all work the roofs will be inspected and must be found in perfect condition. All work must be done in a good, workmanlike, and proper manner throughout, and roofs warranted for one year, and to be kept in good condition during that time by the contractor without extra compensation.

All the above roof, etc., to be made as soon as roof boards are put on.

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Bids will be received for the following items:

Item I. All stone and brick masonry, inclusive of furnishing cut stone, and including whitewashing the walls. Also grading around walls of building.

Item II. All carpenter work, inclusive of door and window frames, sashes, and doors, complete in place, glazed, primed, and painted.

Item III. All slate roofing, copper work, skylights (except iron work of same), lightning rods, and snow guards.

Bids will be received for a single one of the above three items, or for one or more items, or for the work embraced in the three items as a whole.

Bidders will state the time required for the completion of the whole work for which they bid, from the time of commencement.

The contract will provide that the contractor shall conduct his work so as to cause no delay to any other contractor, and that he will have all materials entering into the construction ready for use at such time, before needed, as shall be prescribed by the commanding officer, so as to insure against any delay in the completion of each class of work.

For any delay in the completion of the entire work beyond the date specified in the contract there will be deducted, in the discretion of the Chief of Ordnance, from the contract price the sum of twenty dollars ($20) for each and every day (excepting Sundays) after said date, until the completion of the contract.

Contract will further provide that if in any event the contractor shall delay or fail to commence the performance of the work on the day specified therein, or shall, in the judgment of the commanding officer Watervliet Arsenal, fail to faithfully and diligently prosecute the work to the satisfaction of the United States, then in either case the Chief of Ordnance shall have power either to annul the contract by giving notice in writing to that effect to the contractor, or to proceed to complete it at the expense of the contractor. In either case all money or reserved percentages due or to become due to the contractor shall be forfeited, or so much thereof as may be required to pay the difference between the total amount of the original contract and that required to complete the work under the new purchase or contract, and to pay any damages caused by the said contractor to the other contractors with the United States for the construction of said gun factory; but nothing in these provisions shall be construed as relieving the sureties on the contractor's bond from their obligations. If, however, the contractor is permitted to continue work under his contract, then for any delay in the completion of his work beyond the time specified therein he shall forfeit to the United States the sum of one hundred and fifty dollars ($150) per day for each and every day after that date, until his work is completed.

Contract will also provide that if any doubts or disputes arise as to the meaning of anything in it or any of the papers attached to it and forming part thereof, the matter shall be at once referred to the Chief of Ordnance, U. S. Army, for determination, and the contractor shall abide by his decision. If, however, the contractor shall feel aggrieved at any decision of the Chief of Ordnance, he shall have the right to submit the same to the Secretary of War, and his decision shall be final.

WATERVLIET ARSENAL, *West Troy, N. Y.*

# APPENDIX 32.

## *SPECIFICATIONS FOR GUN LATHES AND OTHER MACHINE TOOLS REQUIRED FOR THE EQUIPMENT OF THE SOUTH WING OF ARMY GUN FACTORY AT WATERVLIET ARSENAL, WEST TROY, N. Y.*

### GENERAL SPECIFICATIONS.

The machine tools are divided into three classes, each class being composed of similar machines, as follows:

Class 1. Turning and boring lathes for guns of 8 to 12 inches caliber.

Class 4. Threading and slotting machines for guns of 8 to 12 inches caliber.

Class 5. Turning and boring laths for jackets up to 16 feet length and 15 tons weight.

Bids will be received for each class separately.

Bidders will state the approximate finished weight of the respective machines their bid is based on, and time of delivery of each machine. All machines to be delivered, erected in complete running order in the Army Gun Factory, Watervliet Arsenal, on masonry foundations prepared by the Ordnance Department.

Payments under the contracts will be made in five (5) installments of *twenty* per cent each, as the work progresses, upon the certificate of the inspector as to the proportionate amount of work done and material on hand from time to time. Ten per cent will be retained from each payment until the final completion and acceptance of each machine.

Insurance must be effected, and, if necessary, renewed from time to time in favor of the Government, subject to the approval of the Chief of Ordnance as to the amount thereof and the companies assuming the risk, sufficient to cover installments paid from time to time, it being understood and agreed that the title of the property in the course of construction shall be and remain in the United States.

In case of failure on the part of the contractor, at any time prior to the completion of the contract, to faithfully perform the obligations thereof, the United States shall be entitled to either enforce its lien on the property, in order to secure the repayment of advances made, or to enter and take possession and complete the work (there or elsewhere) at the risk and expense of the contractor.

In case the latter course shall be adopted, and upon a final accounting to be had between the United States and the contractor after such completion, the total cost of completing the work shall be added to the total amount of advance payments previously made to the contractor. If the cost of completing the work, added to the payments previously made to the contractor, shall be found to be *less* than the contract price, the contractor shall be entitled, upon final settlement, to receive the amount of the difference thus obtained; but if such aggregate shall ex ceed the contract price, the contractor shall reimburse the United States to the amount of such excess.

The partial payments above mentioned will be dependent on the results of tests of physical properties of the material (the United States reserves the privilege to have any of the material tested if required), and in case of completed principal parts of a machine, such as headstocks, carriages, bed, etc., to an inspection when in the contractor's works, where it must be shown to the satisfaction of the inspector that said parts are truly and correctly made of material of required quality, and in accordance with the most advanced and perfect practice in building such machines, and the specifications and drawings. Any work not fulfilling these requirements will be rejected as soon as observed, whether before or after completion of the machines. These inspections and tests will not in any way relieve the contractor of his responsibility under the contract of making the completed machines, when permanently erected in the army gun factory, perform to the satisfaction of the Department, upon final test, all the functions for which they are designed.

The trial of any machine, during the final test, will be completed by the Department with all reasonable promptitude.

No machine shall be unduly tested or be required to do heavier work than that for which it was designed.

The insurance in favor of the United States, aforementioned, must cover the machines while at the contractor's works, while in transit, and during the time they are being erected and tested under the superintendence of the contractor, and until final acceptance.

The last payment, namely, the 10 per cent retainer for each machine, will be made upon its completion and acceptance after final test.

Any defects of material or workmanship, discovered at any time before final payment, must be made good by the contractor, at his own expense, to the satisfaction of the Department, before further payment will be made.

All materials used in the construction of the machines must be of the best quality of their respective kinds.

They must be clean and free of any defects, and especially all finished surfaces and bearings must be clean and true.

All surfaces of contact must have a true and perfect fit throughout; all sliding surfaces must be scraped to a perfect bearing, avoiding any play or looseness which would tend to disarrange the alignment of parts, but free enough to allow all functions of the machines to be performed with perfect ease by avoiding all unnecessary friction and canting.

All cast-iron parts of the machines must be made of close-grained, tough, and hard cast-iron, of a tensile strength of not less than 18,000 pounds per square inch, containing at least 20 per cent of charcoal iron.

All shafts, feed and lead screws, spindles, feed and traversing racks, etc., to be made of forged steel, containing at least 0.5 per cent of carbon.

Centers to be of tool-steel, hardened, with points made to inclose an angle of 60 degrees.

All feeds not specified to be suitable for steel.

All driving-pinions having less than thirty teeth to be made of sound steel castings or forgings, and all other gears to be made of sound steel castings, or of strong, close-grained, tough cast-iron, having at least 20 per cent of charcoal iron.

All gearing of any kind to be accurately cut. All T-slots in bedpieces, etc., to be planed and to have sufficient thickness of metal, and not less than shown in drawing, to prevent breakage. All bolts to be made of steel or refined iron; all nuts to be finished and case-hardened, and to be, as far as possible, of uniform size to require the minimum complement of wrenches, which must be furnished with the machines.

The requirement regarding uniformity of size, especially for those parts employed in handling the machine, are absolute as regards the ends of all carriage-feed screws. Washers of hard vulcanite or similar equally good material are to be employed whenever there is collar friction, provided the end pressure does not exceed the elastic limit of the material, or other means be not provided for taking up all wear due to such friction. All steel shafts to have bronze bearings or bushings, except where otherwise specified or where evidently unnecessary. All bronze to be of hard composition metal, containing 85 per cent of copper and 15 per cent of tin, except where otherwise specified.

All bearings to be on *surfaces* of contact only; none in corners or on edges.

All bearings must be easily accessible for oiling, and ample provisions must be made for oiling all moving parts.

Gear covers or guards to be made wherever the safety of the operator may render it advisable.

To all boring-lathes an automatic oil-pump is to be attached, operated by some part of the machine, to pump the oil into a reservoir during boring.

The top surfaces of the cast-iron supporting-plates resting on the foundation-piers, and the lower or bearing surfaces of the bed of all machines of classes 1 and 4 may be planed or smooth cast surfaces, as the arrangement provided for setting and leveling the bed does not require planed surfaces, if they can be cast level and smooth enough that no part is more out of level than ⅜ inch. The bed will be set and leveled on the supporting-plates by means of set screws provided for in the cross-ties; after being leveled, the bed is bolted to the supporting-plates.

All interspaces between the surfaces of bed and supports are finally, tightly, and uniformly filled with a liquid mixture of sulphur and fine-screened sand (to be furnished by the contractor), in equal proportions.

The appearance of the machines must show superiority in design of ensemble, and details, and workmanship; all their finished and unfinished parts must be neat and smooth, and of a character creditable to the best tool builders of the country.

All finished parts to receive a heavy protecting coat of a mixture of tallow and white lead before leaving the contractor's shops.

All unfinished parts of the machines must receive at least three coats of mineral paint—made up in linseed oil, of approved quality and slate color—one to be a paint-filler carefully rubbed down to an even surface; the last coat to be applied after final completion of the machines.

The contractor must make complete working drawings, such as will enable the Department to examine them before and during execution for the purpose of determining whether the design, size, and finish of parts are suitable.

To prevent any delay in the fabrication of the machines the Department will, upon the notification of the contractor, have the drawings, etc., examined at the place of manufacture. Such modifications of the contractor's designs and finish as will be required by the inspector will be made by the contractor without extra expense to the United States.

The Department reserves the right to make any alterations in the plans, forms, construction, detail, or execution described by the drawings or specifications, without invalidating or rendering void the contract, and in case of any difference in expense, an addition to or abatement from the said contract amount shall be made in the ratio or proportion such work may bear to the whole contract work to be performed.

The parts of the machines, when finished, will be delivered at the contractor's risk and expense, at such places as may be designated, within the army gun factory building, to be there erected by the contractor under his own superintendence.

All skilled and unskilled labor employed in the erection of the machines to be furnished by the contractor. He is to provide all necessary appliances for the erection, and is responsible for any injury to life or limb of his employés.

Railroad tracks run into the building, which is further provided with an 80-ton overhead traveling crane traversing over railroad tracks and places of erection of machines. Said crane may be utilized by the contractor in the erection of heavy parts.

The final test will be made at the expense of the Department, but the contractor will be solely responsible for the care of the machines until their erection, completion, and acceptance by the Department.

The Department will have the masonry foundations for the machines prepared in time for their erection, but the contractor must verify for himself the level alignment of the tops of the foundations and their distances, etc., before he commences the work of erection. In case he discovers any error he will at once inform the Department; otherwise he will be held responsible for the correctness of the level of the foundations.

The contractor will furnish everything pertaining to the machines, except the holding-down bolts of the supporting-plates, which are to be built into the foundation masonry and will be furnished by the Ordnance Department. The plates, Nos. 1 to 11 and 24 to 27, inclusive, represent the principal features of the machines of classes 1 and 4, which, in connection with a complete description of the essential parts, and of all operations the machines have to perform, will give the manufacturer complete information as to the requirements of the Department.

With the exception of details the machines will be made as represented.

As to the details of the mechanism and its arrangement employed for the performance of the various operations, the tool builders are requested to suggest such modifications and improvements as will, in their opinion, and according to their experience, effectively improve the construction.

The Department is confident that mutual efforts in this respect will produce the most perfect machines, combining rigidity, simplicity, and accuracy, with a result gratifying to both the United States and the manufacturer. Bidders are expected therefore to submit with their proposals such drawings and descriptions of detail arrangements and mechanism as will perfect the machines and enable the Department to form a proper estimate of the propositions of the builder.

Whether the Department agrees to such propositions or part thereof or not, the contractor will execute all parts as directed by the Department. The builder is to hold himself responsible for the performance of the different operations of the machines as designed. Bids must be based on the machines shown in the designs of the Department, but if bidders wish they may, in addition to their bid on the above machines, submit any designs which they may deem better than those issued by the Department. But the number and character of the operations of each machine must be limited to those required by the specifications, and all feeds and speeds must be in accordance with those required. Such drawings must show in full all the information necessary to enable the Department to form a correct judgment of the design. The machines of class 5 are intended to be of such standard or commercial patterns as will best conform to the specifications.

In all questions arising under these specifications and drawings with reference to the proper meaning thereof, the decision of the Department shall prevail.

The contractor will furnish to the Department a complete set of blue prints of all working drawings of each kind of machine before the final acceptance of the machines.

All parts of the machines must be manufactured in the United States, and only bids from domestic tool builders of well-established reputation, who are able to convince the Department that their shops are provided with suitable facilities for properly and promptly prosecuting the manufacture of the machines, will be considered.

Preference will be given, other things being equal, to an early delivery of machines of classes 1 and 5, and, generally, such designs as are best suited for the performance of the particular work for which the machines are required will be duly considered in making awards.

For any delay in the completion of the machines beyond the date specified in the contract there will be deducted, in the discretion of the Chief of Ordnance, from the contract price the sum of twenty dollars ($20) for each and every day after said date until the completion of the contract.

Bids will be considered only for machine tools manufactured in the United States.

Contract will also provide that if any doubts or disputes arise as to the meaning of anything in it or any of the papers attached to it and forming part thereof, the matter shall be at once referred to the Chief of Ordnance, U. S. Army, for determination, and the contractor shall abide by his decision. If, however, the contractor shall feel aggrieved at any decision of the Chief of Ordnance, he shall have the right to submit the same to the Secretary of War, and his decision shall be final.

## CLASS 1.

### *Two (2) turning and boring lathes for guns of 8 to 12 inches caliber.*

*Lathes.—The turning and boring lathe* consists of the bed, headstock, tool-carriage, muzzle and breech back-rests, and boring-bar with carriage, and is represented on Plates 1 to 11, inclusive.

*The turning and boring lathe-bed.*—The bed is composed of parts, as follows:

The headstock part 8 feet 5 inches long by 5 feet wide, consisting of a single casting.

The tool-carriage bed is composed of two sections, each a single casting 22 feet 6 inches long by 8 feet wide (3 feet wider than the remainder of the bed), to carry the tool-carriage on independent shears.

The boring-bar carriage-bed is composed of two sections, each a single casting, and respectively 24 feet and 27 feet long by 5 feet wide. The total length of bed is thus 104 feet 5 inches. T-slots run the entire length of the bed sections to admit the squared heads of the bolts clamping down the headstock, tool-carriage, back-rests, and boring-carriage. All sections are connected by 1¾-inch tapered bolts, fitted to holes finally reamed after alignment of the bed; such bolts are to be threaded at both ends, and provided with a nut for each end, for convenience of securing tight fit in the hole before bringing up the nuts.

Transoms or girts connecting the shears are provided at intervals of about 7 feet, their lower portions extending beyond the bed sides for the reception of the bolts employed to fasten the bed to plates which rest on top of the brick piers of the foundation, to which they are in turn secured by foundation bolts and washers. Set screws, whose square heads are provided with locking-washers, also pass through and are employed in leveling the bed.

*The headstock.*—The headstock carries three spindles—the main cone and back gear spindles.

*The main spindle* is to be of hard, close-grained cast iron; the mixture is to contain 25 per cent of cold-blast iron. Front bearing to be 20 inches diameter by 24 inches long, and rear bearing 16 inches diameter by 24 inches long; the distance from center to center of bearings being 6 feet 11 inches. The front end of main spindle carries a *face-plate* of 8 feet diameter. This plate is bored out to fit tight over the nose of the spindle, and is drawn up tight against the spindle-collar by four screws; a taper pin is fitted into the joint of spindle-nose and face-plate bore, and acts as a key. The face-plate is provided with four adjustable chuck-jaws, actuated by screws journaled in the face-plate immediately under their square head, and engaging nuts in the jaw-plates. The jaws themselves consist of the jaw-plate and jaw proper. The former slides in ways in the face-plate and carries the nut, and can be securely clamped by means of six screws, three on each side, engaging rectangular bars lying in T-slots that are formed in the face-plate parallel to the jaw-slide. To the jaw-plate any convenient fixture or style of jaw may be secured by means of four bolts, that shown in the drawing being a jaw having a swiveling grip-piece, enabling the jaw to automatically take a fair grip on the tapered chase of the gun. The main-spindle bearings are to be made of hard, close-grained cast iron, having 25 per cent of cold-blast iron. They are bored straight to fit the spindle, and externally coned to fit the headstock. Each bearing is provided at either end with screw-threads, to which is fitted a spanner-nut. The bearings are longitudinally and radially split entirely through on the bottom, and partially through at lines 120 degrees on each side of this cut. A key is fitted into the headstock to engage the bearing and prevent its rotation. To take up wear, the spanner-nut at the large end of the bearing is slacked off and that on the small end drawn up, thus forcing the bearing farther into the head and compressing it around the spindle. By this arrangement the circular contour of the bearings is always preserved and the center line maintained at a constant height. The rear end of the main spindle is provided with a step, which transfers all end thrust to the thrust-block secured to the rear housing of the headstock. Anti-friction washers of hardened steel and gun bronze are alternately interposed between the step and the adjustable thrust-screw of the block. The step is also made use of to carry a spur-gear, which drives the trains of gearing employed to feed boring-bar and boring-bar carriage.

*The cone-spindle* runs in bronze bearings 12 inches long and 6 inches diameter at front end and 4½ inches at back end; it carries the cone and part of the back-gear train, while keyed to its front end is the face-plate pinion engaging the internal gear, bolted securely to the back of the face-plate.

*The cone* has five steps for an 8-inch belt, ranging from 20.5 to 44 inches diameter.

The cone on the countershaft is a duplicate of the head cone as regards diameters and width of steps.

Keyed fast to the rear hub of the cone is a wide-faced pinion; journaled directly on the cone-shaft is a quill extending through the cone and having the latter journaled upon it. To the rear end of this quill is keyed a pinion of the same diameter as the wide-faced cone-pinion, and keyed to the front end of the quill is a gear close against the front face of the cone. Immediately in front of this gear a gear of the same diameter is keyed to the spindle itself.

*The back-gear spindle* is journaled in bronze bearings below the cone-spindle and on the front side of the headstock, and carries a quill free to rotate about the spindle. Keyed to the rear end of this quill is a gear engaging the wide-faced cone-pinion close to the rear face of the cone, while the forward end of the quill carries securely keyed to it a pinion engaging the gear nearest the front cone-face. The back gear-spindle has keyed to it, immediately behind the front bearing, a pinion of same diameter as that on the quill, which engages with the large gear keyed to front end of cone-spindle. The rear end of the back gear spindle carries a gear engaging the pinion at the rear of the cone-spindle quill; this latter gear is free to slide longitudinally on its spindle, and is provided with a hub extending into the rear bearing. A portion of this hub near the center of its length is spirally grooved, the section of the grooves corresponding to the section of a rack; a pinion, journaled in the bearing and rotated by means of a crank-wrench applied to the squared end of its shaft, engages these grooves and causes the gear to slide along its spindle. When the gear is moved up close to the gear on the end of the quill it engages with the wide-faced pinion on the end of the cone-quill. The back-gear spindle carries on its rear extremity a spur-gear, employed to feed the tool carriage.

The first reduction of speed from the cone is effected as follows: The sliding-back gear is brought forward into engagement with the wide-faced pinion and driven by it. The front pinion keyed to the back-gear shaft then drives the front gear keyed to the cone-spindle, and the face-plate pinion, on the end of the latter, transmits the motion to the main spindle. For the second reduction, the sliding-back gear is moved back and into engagement with the pinion on the rear end of the cone-quill; then the cone-pinion drives the gear on rear of back-gear quill; the pinion on front of this quill drives the gear on end of cone-quill (close to front cone-face); the pinion on rear end of cone-quill drives the sliding-back gear, and the front-back gear spindle-pinion drives front gear on cone-spindle, and this drives again to the main spindle through face-plate pinion and gear.

*The face-plate pinion* has 14 teeth of 1 diametral pitch (3.142 circular), while the face-plate gear has 85 teeth. All the back-gear pinions have 29 teeth of 1.75 diametral pitch (1.795 circular), and all back gears have 77 teeth of the same pitch. All back gears at rear end have 4.5-inch working face and those at front 5.5-inch working face. Width of face of face-plate gear 7½ inches. By employing two main-counter speeds of 165 and 202 revolutions per minute, we obtain 20 main-spindle speeds ranging by practically correct geometrical progression from 0.25 to 10 revolutions per minute.

*The tool-carriage.*—The tool-carriage consists of the plate, bolted to the bed in the desired position; the lower or main slide, which is made to swivel on the plate, and is bolted down to the latter; the lower cross-slide, capable of a longitudinal traverse on the main slide of 15 feet 7.5 inches; the lower cross-shoe, having a movement on the lower cross-slide of 27 inches. The lower cross-shoe carries the second longitudinal slide, which can be made to swivel on the lower shoe, and in turn carries a shoe and allows the latter a longitudinal motion of 3 feet. This shoe carries the upper cross-slide shoe, whose maximum travel is 1 foot 9 inches, though this can be increased by 4 or 5 inches in case of necessity. Two short supplementary slides are mounted on this last slide, each having a travel of 9 inches. The upper surfaces of these slides are faced with 0.5-inch steel plates; four 1½-inch studs are securely tapped in each, and so placed that the lines connecting their centers form a perfect square; each bar is cut out from the hole to the edge on one end, and from the hole to the side edge at the other end, this arrangement allowing the bars to be set in two different positions at right angles to one another without necessitating the removal of the clamping-nuts. Spiral springs slipped over the studs serve to free the tool of the bar when the nuts are being slacked. The upper swiveling-slide carries an extension on its side, to which may be fastened former-plates of any desired shape, the slot formed in such plates being engaged by a conical roller, mounted on a stud, detachably fastened to the end of the upper swiveling cross-shoe; to allow this latter to be drawn in or out to follow the contour of the former, the screw is detached by drawing out a pin which passes through the bushing in which the front end of the screw is journaled and through the body of the shoe. This is accomplished by relieving the thumb-nut shown at the front end of the shoe, sliding it toward the edge and then reclamping. The entire carriage is mounted on a plate which is bolted to T-slots in the carriage-bed shears by means of six bolts, two at each end and two at the center, these latter also passing through the main slide and aiding to secure it to the plate.

Cap-screws passing through slots at the ends (two per end) are, besides, employed to fasten the main slide to the plate. To prevent any possible slight lifting of the front edge of the slide from the plate between the central and end clamping-screws additional screws are located midway between those at the end and center, engaging square nuts lying in slots formed in the base of the plate. The carriage may be shifted longitudinally along the bed by hand, in which case the clamping-bolts are slacked sufficiently to allow the entire weight of the carriage to come on the three pairs of rolls journaled in the main plate. These rolls are hollow and secured to axles. The radii of the rolls are slightly greater than the distances from the shears to the roll-centers, so that clamping the plate down compresses the rolls, which will, on the bolts being loosened, regain their original shape, at the same time raising the carriage clear of the shears. A pinion journaled on the front side of the plate, near the center of its length, engages a rack fastened to the front side of the carriage-bed, and will, when rotated by a ratchet-wrench applied to the upper squared end of its shaft, feed the carriage along. The rear end of the slide has formed on it a vertical gear-segment, into which meshes a pinion provided with a squared end for the attachment of a wrench, to be employed in swiveling the slide after the bolts clamping it to the plate have been slacked. This end of the slide is graduated to give variations of taper in diameter of 0.0002 inch per 1 inch of length, the graduations to extend 2½ degrees each side of O in the plate. Automatic feeds in two directions are provided for the two longitudinal and the lower cross-slides; and motion for these feeds is derived from the splined shafts extending the entire length of the tool-carriage bed and by mechanism, as follows: A miter-pinion journaled in a bearing projecting from the under side of the bed-plate derives motion from the splined feed-shaft, along which it is free to travel with the carriage, transmitting this motion to a miter mounted on the lower end of a short vertical shaft extending through and journaled in the swivel of the main slide, and carrying at its upper end a miter-gear, which in turn rotates a feed rod lying in the trough of the slide parallel to and nearest the inner way, by means of a miter splined to the shaft and journaled in the slide. Mounted on the outer end of this rod is a spur-gear which drives a splined shaft extending the entire length of the slide. A gear on the end of this second shaft in turn imparts rotation to an intermediate loosely mounted on the end of the first shaft. When this clutch is slipped on the opposite end of the screw the rotation of this intermediate gear drives a gear loosely mounted on the end of the screw journaled parallel to the spline rod and extending the entire length of the slide. This gear has clutch teeth on its hub, which may be engaged by corresponding teeth on the face of a removable clutch, which is in engagement with the screw by means of a feather. The latter is reversed, being then driven by means of an intermediate from a gear permanently mounted on the corresponding end of the spline rod, and as the screw engages a nut secured to the base of the slide-shoe, this latter is fed in either direction desired.

One clutch only is provided, to guard against accidents resulting from an attempt to rotate the screw in opposite direction through neglect of the operator to remove one or the other. In the drawings such removable clutches are shown in position by dotted lines. Extending through the bottom of the lower cross-slide is a short, vertical shaft carrying miter-gears on either end, the lower one of which engages a gear journaled in the bottom of the slide, and driven by the splined shaft extending the entire length of the main slide, while the one at the upper end engages a miter-gear journaled in the recess in the upper portion of the cross-slide and drives a splined rod lying in the trough of the slide parallel to and nearest its left-hand way. The two rods and the screw in this slide serve the same purposes and are actuated by gearing in a similar manner as those in the main longitudinal slide. A bevel-gear splined to the central rod and journaled in the base of the cross-slide swivel plate drives (by means of a gear at the lower end of a vertical shaft extending through the center of the swivel and a miter-gear at the upper end of this shaft) a miter-gear journaled in the upper slide and splined to a shaft extending the entire length of this slide. Mounted on each end of this shaft are spur-gears, the one at the front driving a screw that is journaled in the slide parallel to the rod, through a removable gear that can be placed on the squared end of the screw, while the gear mounted on the rear end of the rod drives the screw through the same removable gear, by means of an intermediate gear centrally between the screw and rod; by varying the position of this removable gear, rotary motion in opposite directions is imparted to the screw and the slide-shoe fed in the direction desired. Hand-feed is provided by using a crank-wrench on the squared end of the feed-screws in place of the removable gears. The feed-screws have a lead of ½ inch per revolution and a single bastard-thread. All slides are provided with tapered bronze keys extending the entire length of the shoes to compensate for wear. The long tapers on the chase of the gun are turned by swiveling the main slide on the plate, while a former is employed as described for the other irregular outlines. When the former attachment is not in use a flat plate is fitted in place of the former plate to make a bearing for the upper cross-shoe on its inward travel. When it is desired to travel the tool-carriage past such fixtures on the main bed which would prevent the passage of the tool-carriage in its ordinary position, the latter is moved along as far as such fixture will allow; the lower main slide is then swiveled sufficiently to clear the fixture, returning all parts to their original position after passage of the obstruction.

Tool-carriage feed mechanism for turning and screw-cutting. Motion is conveyed to the feed driving-shaft, which lies in the tool-carriage bed, from the spur-gear mounted on the end of the back-gear spindle. This gear drives through compound gearing and an intermediate, mounted on a sweep, a change-gear mounted on the end of a shaft lying parallel to the head along the front side of the headstock bed; this shaft carries near its rear end a spur-gear, driving another gear of the same size whose hub is journaled in the second bearing of the main feed-shaft, and one of whose hub faces is provided with clutch teeth. The shaft, journaled in front of and parallel to the headstock bed, carries also a worm which drives a worm-gear, the latter having at its end a miter-gear engaging a miter journaled in the end-bearing of the main feed-shaft, and provided with clutch-teeth on its hub end. A clutch splined to the feed-shaft can be made to engage either this last-mentioned miter-gear or the spur-gear, by means of a suitable lever, as shown, thus conveying rapid rotation to the main feed-shaft by the spur-gears, or motion 12½ times as slow through the worm and miter-gearing. The fast speed is employed for screw-cutting, while the slow one gives the turning feeds. By use of the gears mentioned in table on the diagram, screw-threads, having a lead per revolution of 0.25, 0.3, 0.4, 0.5, 0.6, 0.7, 0.75, 0.8, 0.9, 1.0, 1.25, 1.50, 1.75, etc., up to 3 inches, varying by quarters of an inch, can be obtained, while still others may be had by the use of suitable gears. Cutting-feeds will range from 0.02 up to 0.24, the change from screw-cutting to turning being simply and rapidly effected by throwing out the clutch mentioned, while by leaving it in the central position the feed-shaft receives no motion whatever.

*Boring-bar carriage driving and feed mechanism.*—The boring-bar carriage is mounted on the main bed and bolted to the latter by bolts engaging T-slots running the entire length of the shears. The sections are securely bolted together by taper-bolts to preserve their relative alignment. A housing carrying part of the gearing for conveying feed-motion to the boring-bar and the pulleys for rapidly moving the same are bolted to the rear end of the carriage—forming a part of the same—and also to the bed. The boring-bar is of forged steel, 45 feet 8 inches long by 7½ inches diameter, and has a 4-inch hole extending its entire length, and its front end is tapered out for the reception of the shank of center or tool-head. It is supported by four capped bearings, the first one of which is stationary at the front end of the carriage; two intermediate ones are set at equal intervals between the first and fourth, to which last the boring-bar is secured between collars. All heads are bushed, the external diameters of the bushings being sufficiently large to permit the use of bushings for an 11-inch bar, should it be found desirable to use one. All heads are adjustably gibbed to the carriage. As the last head moves forward, carrying the bar with it, it comes in contact with the third, pushing that with it, and this will in turn carry along the second; when returning, the third head draws the second back, releasing it at its normal position, being in turn released by the last head at the proper time. To accomplish this a pair of drag-hooks are bolted to the front end of the last head, terminating in beveled surfaces, which serve to raise and conduct into the hooks a transverse bar lying in suitable recesses under the third head; this bar extends the entire width of the space between the carriage-shears, on the inner sides of which are formed at a suitable point lugs beveled toward the front, which serve to lift the bar out of the drag-hooks as it is carried over them by the return movement of the head. A similar arrangement is made use of between the second and third head. A screw extends the entire length of the carriage between the shears, and is journaled at the rear in the housing bolted to the carriage, and supported on each carriage-transom by a bearing embracing one-third of its circumference; a nut engaging the remaining two-thirds is attached to the rear head; this nut is made in halves, which are connected by a right and left hand screw, to allow ready detachment of the head from the screw. Loosely mounted on the rear end of the screw are a pair of friction-pulleys (which must be what are termed "rim-frictions" of approved design), which impart rapid rotation to the screw in different directions, on being set up by the usual spool sliding on the screw between them. For the boring and reaming feeds the screw carries in the rear housing, and in front of the friction-pulleys, a pair of loose miter-gears provided with clutch-teeth on their inner faces for engagement by the clutch splined to the screw between them; these miters derive rotation from a third miter mounted on the upper end of a vertical shaft journaled in the housing, and carrying at its cone end a miter-gear driven from its mate mounted on the inner end of short horizontal transverse shaft, receiving motion from a worm driving a worm-gear mounted on the short shaft. The shaft carrying the worm is splined and extends the entire length of the main bed through to the head end, being supported by automatic drop-bearings for that portion of its length traversed by the boring-carriage.

Rolls situated in the feet of the boring-carriage and journaled in spring frames serve to take the weight of the carriage, when the clamping-bolts are slacked, to permit of a free movement along the main bed by the operator, who rotates a short vertical shaft near the front end of the carriage by means of a ratchet-wrench applied to its upper square end; mounted on the lower end of this shaft is a pinion which engages a rack secured to the inner main bed-shear. For power-traverse of the carriage, a miter-gear is keyed to the above-mentioned short vertical shaft, which is driven by its mate on the forward end of a horizontal transverse shaft having loosely mounted upon it, near the back, a pair of miter-gears connected by a third, vertically journaled underneath them; the two miters on the shaft have clutch-teeth formed on their inner faces, for engagement by a sliding clutch splined to the shaft, and operated by a bell-crank lever extending through the front side of the carriage within convenient reach of the operator. A worm-gear keyed to the hub of the rear end of the clutch-miters is driven by a worm on the splined feed-shaft lying in the main bed. A light rod made of tubing runs along the front side of the carriage, and is connected at the front end to a handle pivoted on the carriage, by which it is thrown to the right or left, engaging the gear or pulley, giving a back or forward motion to the bar. Adjustable dogs on this rod are struck by a tappet attached to the rear bar-head, thus automatically controlling the length of the stroke. The shifting mechanism is so arranged that it is impossible to engage two feeds or any feeds in different directions simultaneously; a portion of the rod at its rear end, and a portion at the front of housing and carriage is squared, and slides through square bearings, that portion of each square which rests in these bearings, when both clutches are thrown out of engagement, being turned cylindrical to permit rotation of the rod; when in that position, by means of a handle attached to its front end—the normal position of the operator—a portion of the rod centrally between these two squared portions carries a spline on each side of a short bearing set in the center of this section, which splines are in line with key-ways cut through the bearing only when the rod is rotated to either limit, thus permitting an endwise movement of the rod at such time only; those portions of the rod in front of the gear-clutch and friction-spool are cranked in opposite directions, the cranks being arranged to stand vertical when the rod is at either limit of its angular movement; on each side of the center of each crank are lugs projecting from it and away from the rod; these lugs, when the cranks are thrown up, engage the end of the forked levers attached to the gear-clutch and friction-spool, which levers swing on vertical pivots between the rod and screw, and whose rear ends—or those portions engaged by the lugs on the cranks when thrown up—are horizontally pivoted, and will, when the cranks are thrown down, drop into locks, thus preventing any possible movement of the levers around their vertical pivots, tending to shift clutch or spool; to further insure this locking, yokes are attached to the cranks and passed over the top of the rear portion of the forked levers, compelling their downward movement in unison with that of the cranks; a further advantage of the use of these yokes lies in the fact that it will be impossible to rotate the rod and shift it endwise should any accidental obstruction prevent the safe locking of either lock.

Motion is imparted to the shaft lying in the main bed from the live spindle by the spur-gear on the step, and some intermediate spur-gears, all of which also form part of the tool-carriage feed-tram; this last bevel-gear has formed on it a spur-gear, and keyed to the hub of the last spur-gear is a spur-gear of half the diameter of the other; these two spur-gears are in engagement with a pair mounted on a shaft below and to the left in such manner that one or the other can be connected to the shaft by a spline, or both disconnected, imparting to the shaft two different speeds, one four times as fast as the other, or permitting the shaft to remain idle while the gears simply rotate around it.

Permanently keyed to this shaft is a cone of four gears, which drives a cone of four similar gears mounted on the end of the long splined feed-rod extending the length of the main bed; these last gears are also so arranged that any one of them can be at will locked to the shaft, imparting to it its rotative speed, giving eight different feeds to the boring bar.

The device employed to engage any one of a nest of gears is shown on Plate No. 5. It must be arranged so as to prevent possible engagement of two gears simultaneously. The projecting portion of the spline-rod is provided with rack-teeth; the teeth to be engaged by a pinion for the easier movement of the rod in changing the feed.

### BREECH AND MUZZLE BACK RESTS.

*The breech-rest.*—The breech-rest consists of a housing in two parts, base and top, and the chuck-ring, also made in two parts for convenience in placing or removing the gun. It is bolted to T-slots in the bed by 1¼-inch bolts in the desired position, and can be moved along by hand by applying a rachet-wrench to the squared end of a short, horizontal, transverse shaft journaled in the base of the rest and terminating in a miter-gear engaging a similar gear at the upper end of a short vertical shaft that carries a pinion engaging a rack secured to the front shear and extending the entire length of the bed traversed by the back-rests. The upper part of the housing is bolted to the base by means of two 1¼-inch eyebolts hinged in the latter. The chuck-ring is made in halves, that are bolted together by four eyebolts, all hinged in the lower half. The ring is flanged on both sides, and the portion between the flanges turned to journal in the housing. Six slides in the front ring-flange are provided, to which the jaws are fitted and adjusted by square-ended screws 1¼ inches diameter, journaled at the periphery of the flange and engaging half nuts in the jaws, which latter are firmly bolted to the ring by four 1¼-inch studs for each jaw, set into the ring, and passing through slots at the sides of the jaws. Each jaw carries a 2½-inch screw terminating in a squared outer end; these screws take the bite on the breech of the gun.

*The muzzle-rest.*—The muzzle-rest is mounted on the rear portion of the bed and bolted to the T-slots in the shears by 1¼-inch bolts. It is moved along the bed by a pinion engaging the rack in the same manner as the breech-rest.

*Automatic releases or breaking-pins.*—Automatic releases (of approved designs) or breaking-pins must be provided in the carriage driving-feed (for turning and screw-cutting)—preferably on one of the first driving-gears of carriage—of all machines of classes 1 and 2; also in the boring-bar feeds (fast and slow), and in the driving bearing of boring bar of all machines of Class 1, to permit free rotation of bar with face-plate in case of accident.

## TURNING AND BORING LATHE.

### *General dimensions.*

Speed of main counter, 166 and 202 R. P. M.
R. P. M. of main spindle from 0.25 to 10—20 speeds.
Cones, 5 steps of 20.5, 26.46, 32.43, 38.21, and 44.0 for 8-inch belt.
Cone-pinion, 9.25-inch face, 29 teeth,
Cone-quill pinion, 4.75-inch face, 29 teeth,
Cone-spindle gear, 5.5-inch face, 77 teeth,
Cone-quill gear, 5.5-inch face, 77 teeth, } 1.75-inch diametral pitch.
Back-gear spindle-gear, 4.5-inch face, 77 teeth, } 1.795-inch circumferential pitch.
Back-gear quill-gear, 4.5-inch face, 77 teeth,
Back-gear quill-pinion, 6-inch face, 29 teeth,
Back-gear spindle-pinion, 6-inch face, 29 teeth,
Face-plate pinion, 7.5-inch face, 14 teeth, } 1-inch diametral pitch.
Face-plate gear, 8-inch face, 85 teeth, } 3.14-inch circumferential pitch.
Main spindle front bearing, 20 inches diameter by 24 inches long.
Main spindle back bearing, 16 inches diameter by 24 inches long.
Cone-spindle front bearing, 6 inches diameter by 12 inches long.
Cone-spindle back bearing, 4.5 inches diameter by 12 inches long.
Back-gear spindle front bearing, 5.5 inches diameter by 12 inches long.
Back-gear spindle back bearing, 6.5 inches diameter by 14 inches long.
Face-plate, 8 feet diameter.
Vertical height from top of shear to center, 4 feet.
Range of tool-carriage on bed, power and hand, 24 feet.
Travel of main longitudinal slide, power and hand, 15 feet 7½ inches.
Travel of main lower cross-slide, power and hand, 2 feet 3 inches.
Travel of second longitudinal slide, power and hand, 3 feet.
Travel of upper cross-slide, 1 foot 9 inches.
Travel of upper auxiliary cross-slides, each 9 inches.
Free swiveling motion of main longitudinal slide, each side of 0 to 2½ degrees.
Free swiveling motion of second longitudinal slide, each side of 90 degrees.
Power-feed per revolution of gun from .02 to .24 inch.
Lead per inch of threads to be cut, 0.25, 0.3, 0.4, 0.5, 0.6, 0.7, 0.75, 0.8, 0.9, 1 inch, 1.25, 1.50, 1.75, 2, 2.25. 2.50, 2.75, and 3 inches.
Boring-bar, 45 feet 8 inches long, 7.5 inches diameter, 4 inches clear hole.
Boring-bar travel, 40 feet.

Boring-bar feeds, per revolution of gun, 0.008, 0.012, 0.017, 0.024, 0.031, 0.045, 0.064, and 0.093 inch.
Boring-bar feeds, per hour at 60 revolutions of gun, 0.5, 0.72 inch, 1.03, 1.49, 1.87, 2.71, 3.86, and 5.58 inches.
Boring-bar rapid traverse forward, 28 F. P. M.
Boring-bar rapid traverse backward, 56 F. P. M.

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|---|---|
| Boring-bar rapid traverse pulleys on machine, 24 inches diameter, | belt 8 inches wide. |
| Boring-bar rapid traverse pulleys on counter, 18 and 36 inches diameter, | |

Boring-bar rapid traverse counter, 448 R. P. M.

| | |
|---|---|
| Headstock bed section | 8 feet 5 inches x 5 feet. |
| Tool-carriage bed section, two at 25 feet 6 inches | 45 x 8 feet. |
| Boring-bar carriage bed section, one at 24 feet and one at 27 feet | 51 x 5 feet. |
| Total | 104 feet 5 inches. |

Maximum diameter taken in by face-plate chuck, 50 inches.
Minimum diameter taken in by face-plate chuck, 10 inches.
Maximum diameter taken in by breech-rest, 48 inches.
Minimum diameter taken in by breech-rest, 30 inches.
Maximum diameter taken in by muzzle-rest, 26.5 inches.
Minimum diameter taken in by muzzle-rest, 12 inches.

## CLASS 4.

### *One (1) Threading and Slotting Machine for Guns of 8 to 12 inch Caliber.*

(Plates 24 to 27, inclusive.)

This machine consists of—

1. Bed and supports.
2. Threading and slotting driving mechanism.
3. A breech back-rest or rotating chuck with block-threading tool-slide.
4. A muzzle back-rest.
5. Threading-counter.
6. Slotting-counter.

#### ARRANGEMENT FOR THREADING THE BREECH.

(As shown on general plan of machine.)

The gun is supported in two rests, one at the chase and the other at the breech; both are bolted to the bed. The gun will be centered by rotating the breech-rest chuck, and with it the gun, either by power or hand, while testing its alignment.

A former-screw, of the same pitch as the thread to be cut in the breech of the gun, is then attached to the tool-bar that carries the threading tool, causing the latter to be fed forward, while it receives rotation from the threading counter, three different speeds being provided.

The length of travel of the threading bar is automatically governed by tappet and dogs, previously set by the operator; the gun, of course, remains stationary during the entire operation.

#### ARRANGEMENT FOR SLOTTING THE BREECH.

The guide-screw is replaced by a rod connecting the tool-bar previously used to carry the threading tool, but now provided with a slotting tool, to a crank-disk, at such a distance from the center of the latter as is necessary for the required stroke; the mechanism conveying continuous rotating motion to the tool-bar from the threading counter is thrown out of operation, while the slotting-counter imparts rotation to the crank-disk. An adjustable intermittent feed rotation is given the tool-bar, speed of stroke is *constant, and same for cut and return.*

### ARRANGEMENT FOR THREADING BREECHBLOCKS.

A steady ring is centrally secured in the breech-rest, providing a support for the outer end of the arbor which carries the breechblock, that is secured to the tool-bar of the machine. A tool-rest attached to the bed and breech-rest carries a compound slide, to which a threading tool is attached, the latter to be fed up to its work in much the same manner as is the case in an ordinary lathe; the block, itself rotating, is fed forward at the rate of the required pitch, in unison with the motions imparted to the tool-bar, and in precisely the same manner as was the case when the machine was rigged up for threading the breech in the gun.

### ARRANGEMENT FOR SLOTTING THE BLOCK.

This threading tool carried by the tool-rest on the breech-rest is replaced by one suitable for slotting, and the block fed past it and intermittently rotated for the feed, receiving these motions in the way described in using the machine for slotting the breech in the gun.

### THE BED AND SUPPORTS.

The bed is composed of two sections having T-slots extending to the forward end of housing. The second section carries the threading and slotting housing and conforms in shape to the base of the latter. Both sections have horizontal transverse openings in their planed-joint faces, into which keys for preserving their alignment are fitted; they are drawn together by means of heavy links and wedges terminating in screw-ends passing through the side of the beds and provided with nuts allowing ready access. Transoms or girts connect the shears at intervals of about 7 feet and project a short distance from the sides of the bed for the reception of 1¼-inch anchor-bolts and 1-inch leveling screws. Bolted to the top of each foundation pier is a cast-iron plate on which the transom rests directly and to which it is bolted by 1¼-inch bolts.

### THREADING AND SLOTTING DRIVING MECHANISM.

The largest portion of the mechanism connected with the threading and slotting operations is contained in a single housing or frame mounted at the head end of the bed. A horizontal transverse shaft mounted near the working end of the housing carries a three-step friction cone and single pulley on opposite sides of the usual spool employed for engaging one or the other of the rim-frictions of approved design, coupling them to the shaft. A worm on this shaft is in engagement with a worm gear mounted on and splined to the hollow steel tool-bar, which is free to slide through it. The front end of this bar has a taper socket for the reception of the shank of the arbor, supported at its outer end in a steady-ring set into the bore of the gun.

A former screw, having the same lead as the thread to be cut, is fastened in a stud, sliding in a slot extending half way across the face of a horizontal disk, mounted on a vertical shaft journaled in the rear end of the housing; the stud and disk serve in this case merely to hold and adjust the end of the guide-screw, being actively employed only in the slotting operations. As used at present, the disk is turned to a position in which the slot across the face points away from the tool, the stud in the slot being carried to such position as required by the starting point of the thread in the gun or on the breechblock, the disk meanwhile being securely locked to the housing of the machine. The former-screw passes through former-nut secured to the rear end of the tool-bar by keys passing through both and at each side, and held by nuts at their ends. A former screw and nut must be provided for each of the three pitches to be cut. They must be very accurately made and have a closely and uniform working fit throughout.

Former screws and nuts must be provided for pitches of 0.7 and 0.96 inch right-hand thread and for 1.17 inches right and left hand thread, these screws and nuts to conform in all details to those in application with the machines of the same type in the possession of the Department now. A vertical lever projects out of the top of the housing near the left-hand front corner, within convenient reach of the operator normally stationed there; this lever is pivoted and is connected at its lower extremity by means of a rod to a horizontal bell crank, transferring motion to a vertical lever pivoted near the base of the housing, directly underneath the center of the spool employed to set the friction in the driving cone for cutting or pulley for reversing. Attached to the first arm of the bell crank is a shipper rod that passes along the top of the housing in front of and parallel to the former screw, sliding through bearings formed on the upper surface of the housing; dogs that can be set on this rod at points required by the stroke, one on each side of the former nut, are struck by a collar provided on the nut for the purpose, disengaging the frictions at the completion of each stroke. To slot the breech, the threading tool is taken off its spindle and replaced by one suitable for slotting. The spool setting out, the friction is brought to the central or nonoperative position, leaving the worm shaft free to receive intermittent rotation for feed. At the rear end of the housing a horizontal shaft is journaled, carrying a tight and a loose pulley, which are driven from an overhead counter. The tight pulley is keyed on a sleeve running loose on the shaft. To this sleeve is fixed a spur gear driving another below it on a short horizontal shaft, and the outer end of which is another spur gear driving one keyed to the outer end of the shaft carrying the pulleys. This shaft carries a bevel pinion that drives a bevel gear formed on the under side of a horizontal disk, which is in turn mounted on the upper end of a vertical shaft journaled in the housing; this disk is slotted from the center to the periphery, and a stud set to any position from the center by means of a screw terminating in a squared end projecting from the periphery, and this stud is pivoted to the rear end of a rod connecting the crank disk and tool bar. The forward end of this rod is free to swivel on a pin secured in a short trunk bearing that rests against a bronze ring interposed between it and the rear end of the tool bar, while the rear flange of an external bushing keeps this trunk up to the bar on the return stroke; the connecting rod takes the place of the former screw, and the external bushing that of the former nut used in threading, the bushing being secured to the bar in the same manner and by the same keys employed with the former nut.

A disk having a cam-slot in its upper face is keyed to the vertical crank-shaft, and the cam-slot engaged by a roll on one leg of a bell-crank, which gives one pull for every stroke of the bar to a feed-rod extending along the front side of the housing, and connected at its forward end to a nut set in any desired position on the face of a slotted disk by means of a screw terminating in a knurled handle; this disk is loosely mounted on the front end of the worm-shaft, and is given partial revolution for the feed through the medium of right and left pawl in the disk, that can be thrown into engagement with the double-acting ratchet keyed to the end of the worm-shaft. To prevent possible interference of this feed with the worm-shaft when the latter is continuously rotated in threading (by accidental engagement of ratchet and pawl), the feed-nut should be carried to the center. The lever for shifting the slotting-belt projects from the front side of the housing conveniently for the operator, and is fastened to a rock-shaft extending back in the housing, and terminating in a lever engaging the belt-shipper rod by a fork. The shipping lever is locked by means of a knurled handle located at the front end of the housing, which engages by a screw a yoke passing over the lever and holding the same in the desired position. The lower end of the vertical crank-shaft is stepped on a pair of disks, one steel and one bronze, resting on the end of an adjusting screw. A miter-gear above the step bearing on the crank-shaft drives through its mate a longitudinal horizontal shaft journaled in the base of the housing and extending forward. The miter on this last shaft is keyed, but free to slide out of mesh with its mate, this being accomplished by a forked lever engaging a groove in the hub of the wheel, pivoted in the housing and extending through it; an ordinary spoon and pin latch is made use of to lock this lever. Keyed to the front of the shaft is a spur-gear engaging another keyed to a horizontal shaft journaled in the bed, along a spline on which a spur-gear conveying motion to one journaled in the base of the breech-rest is free to move with the latter.

*The breech-rest and the tool-rest.*—The breech-rest consists of a housing in two parts, base and top, and the shank-ring, also made in two parts for convenience in placing or removing the gun. It is bolted to T-slots in the bed by 1¼-inch bolts in the desired position, and can be moved along by hand by applying a ratchet-wrench to the squared end of a short, horizontal, transverse shaft journaled in the base of the rest and terminating in a miter-gear engaging a similar gear at the upper end of a short vertical shaft that carries a pinion engaging a rack secured to the front shear and extending the entire length of the bed traversed by the back-rests. The upper part of the housing is bolted to the base by means of two 1¼-inch eyebolts hinged in the latter. The chuck-ring is made in halves that are bolted together by four eyebolts, all hinged in the lower half. The ring is flanged on both sides, and the portions between the flanges turned to journal in the housing, a segmental gear being bolted to its central part, which is engaged by the pinion journaled in the base, thus allowing the chuck to be rotated by power or hand, as may be desired. If power is to be employed, it is derived from the pulleys driving the slotting mechanism, in which case the crank end of the connecting-rod must be set over the center of the crank-disk; if the ring is to be rotated by hand, a wrench is applied to the squared end of the horizontal shaft, journaled in the housing containing the slotting and threading mechanism. Slides in the ring-flanges are provided, six in each flange, to which the jaws are fitted and adjusted by square-ended screws, 1¼ inches diameter, journaled at the periphery of the flanges and engaging half nuts in the jaws, which latter are firmly bolted to the ring by four 1¼-inch studs for each jaw, set into the ring, and passing through slots at the sides of the jaws. Each jaw carries a 2½-inch screw terminating in a squared outer end; these screws take the bite on the breech of the gun. A compound slide for the block-threading and slotting tool is located on a rest bolted to the base of the breech-rest at the working side and to the bed. The tool is laid in a shallow 2½-inch wide slot in the surface of the bar and secured in the usual manner by two clamp-bars and four 1½-inch studs. When not in use for threading and slotting blocks, the upper half of the tool-rest with compound slides is to be removed to clear the breech of the gun.

*The muzzle-rest.*—The muzzle-rest is mounted on the rear portion of the bed and bolted to the T-slots in the shears by 1¼-inch bolts. It is moved along the bed by pinion engaging the rack in the same manner as the breech-rest, the transverse shaft driving the pinion extending entirely through the base and terminating in a square at each end. It is otherwise constructed similarly to the breech-rest, but provided with six jaws only, all located on the same flange of the jaw-ring; the mechanism rotating the ring by hand or power is omitted.

*The threading counter.*—The threading counter carries a cone similar to that on the machine, a return driving pulley, and tight and loose pulleys for open and crossed belts, driven from the line-shaft, and convenient mechanism for shifting the belt.

*The slotting counter.*—The slotting counter has a pulley for the belt leading to the machine, and tight and loose pulleys driven from the line-shaft, with convenient mechanism for shifting the belt.

### GENERAL DIMENSIONS, ETC.

Cutting R. P. M. tool-bar, 2.38, 3.44, and 4.96.
Return R. P. M. tool-bar, 4.96.
Maximum travel of tool-bar threading, 26 inches.
Threading counter, R. P. M., 203.
Threading cone, 18, 22, and 26 inches diameter, } 3-inch belt.
Threading return-pulley, 18 inches. }
Slotting bar, maximum travel, 26 inches.
Rate of bar, maximum travel, 16 F. P. M.
Slotting counter, 65 R. P. M.
Slotting pulleys on machine, 30 inches diameter, } 4½-inch belt.
Slotting pulleys on counter, 20 inches diameter, }
Slotting feed per stroke, maximum, =0.135-inch.
Slotting feed per stroke, minimum, 0.007-inch.
Vertical height from top of shears to center, 48 inches.
Capacity of breech-rest, 30 to 48 inches diameter.
Capacity of muzzle-rest, 12 to 26.5 inches.
Length of bed, 38 feet 10 inches.
Depth of bed, 20 inches.
Diameter of tool-bar, 8.5 inches.
Diameter of former-screws, 5 inches.
Pitches of former-screws, 0.7, 0.96, and 1.17 inches.
Diameter of arbor passing through steady-ring, 4 inches.
Slotting connecting rod of elliptical cross-section, maximum and minimum axis, respectively, 4 and 2 inches.

## CLASS 5.

### SPECIFICATIONS.

### *For two (2) jacket lathes for turning and boring work of 16 feet length and 15 tons weight.*

This lathe is to swing not less than 60 inches over the ways and 48 inches over the carriage, and to take work weighing 15 tons between centers. It must be provided with a boring arrangement for boring lengths of 16 feet, and the distance between centers of live-spindle and boring-bar should be not less than 19 feet.

*Driving cone.*—To have 5 steps for not less than 4½-inch belt; diameter of steps approximately from 15 to 25 inches.

*Cone.*—To be strongly back-geared, giving 15 changes of speed by means of triple gearing to face plate. Means to be provided for making these changes very quickly and easily. Face-plate gear and pinion to have not less than $1\frac{1}{2}$-inch pitch and $4\frac{1}{2}$-inch face, and to have with this pitch approximately 120 and 20 teeth, respectively. Cone to be geared to face-plate in ratio of not less than 20 to 1 for fast train and in ratio of not less than 70 to 1 for slow train.

*Spindle.*—To be made of close-grained cast-iron, having not less 25 per centum of cold-blast charcoal-iron in its composition. Front spindle-bearing to be not less than 10 inches diameter by 12 inches long. Back spindle-bearing to be not less than 7 inches diameter by 10 inches long. Length of spindle in bearings to be not less than 54 inches. Spindle to be provided with a flange to which face-plate is bolted, and fitted with steel bush in front end to receive center.

*Spindle-bearing.*—To be made in halves and capped. To have heavy flanges on the ends and made of hard, close-grained cast-iron, the same as specified for spindle. The back end of spindle to be provided with a thrust-bearing of ample surface, well provided with antifriction washers and arranged to hold a sufficient quantity of lubricating oil.

*Face-plate.*—To be bolted to spindle. To be not less than 60 inches in diameter, provided with slots for clamping work, and with four adjustable steel jaws of large proportions, arranged to be set up by strong screws from the back. Chuck-jaws to take in work ranging from 20 to 42 inches in diameter. They are to be hardened, with faces V-shaped or grooved, to insure a satisfactory grip on the work. The face-plate gear is to be a separate casting bolted to the face-plate.

*Centers.*—To be of first-class quality of tool-steel, not less than 3 inches in diameter, hardened, and pointed to inclose an angle of 60 degrees.

*Turning and screw-cutting feeds.*—All feeds to be automatic, positive, and driven by change-gears from the headstock. Headstock to be provided with reversing-gear for reversing direction of screw-cutting and turning feeds. The thread on lead-screw to be used only for screw-cutting, and the lead-screw nut and feed-gearing in carriage-apron to be so arranged that screw-cutting and turning feeds can not be thrown into gear at the same time. Turning-feeds to range from $\frac{1}{40}$ inch for the finest to $\frac{3}{8}$ inch for the coarsest. Change-gears for screw-cutting to be provided for changing pitches by $\frac{1}{10}$ inch and $\frac{1}{8}$ inch, and for cutting screw-threads ranging from $\frac{1}{20}$ inch and $\frac{1}{16}$ inch for the finest to 1 inch for the coarsest.

*Boring-feed.*—To be automatic, positive, and driven by gearing from the headstock. At least eight changes to be provided, ranging from $\frac{1}{100}$ to $\frac{16}{100}$ inch per revolution of face-plate.

*Material for gearing.*—All pinions of less than 30 teeth to be made of sound steel casting or forging. All other gears to be of strong, close-grained cast-iron, containing 25 per centum of charcoal-iron. All gearing throughout to have teeth accurately cut.

*Lead-screw.*—To be of steel, at least 3 inches in diameter and $\frac{1}{2}$-inch pitch, fitted with a bronze nut not less than 10 inches in length.

*Feed-rack* for carriage-feed to be of steel, not less than $2\frac{3}{4}$-inch face and $\frac{3}{4}$-inch pitch.

*Apron-gears* and bearings to be strongly proportioned and accessible for oiling.

*Carriage.*—To be arranged to turn work of 16 feet length supported on face-plate at one end and in steady-rest on the other end. To have bearings on bed not less than 68 inches long, and fitted on very broad vees. To have hand movement by gearing connected with feed-rack on bed. To be provided with one heavy compound-rest, having base not less than 20 inches wide by 26 inches long, and fitted to cross-slide of carriage. To be provided with longitudinal feed on bed, cross-feed for compound-rest, and feed to the upper tool-slide—all automatic, operated by gearing, splined screws, and rods.

*Bed.*—To be not less than 48 inches wide and 18 inches deep, and fitted with ways for head and tail stocks, carriage, and boring-carriage. Bed must be well extended to the front, so that the line of strain when turning the full diameter of swing will fall inside the front way thereof. Cross-girts in bed to be of strong section and spaced about 24 inches between centers.

*Tailstock.*—There is only one tailstock required for both lathes of this class which must have a true fit on the ways of either lathe. Bearing on bed to be not less than 38 inches long by 34 inches wide. Tailstock to be provided with convenient set-over, and held down by at least four strong bolts. It is also to be provided with means for moving it easily along the bed by hand, either by gearing into the rack on bed or by mounting on rollers running on the bed.

Tail-spindle to be of steel not less than 6½ inches diameter, and provided with center same as specified for headstock spindle.

*Steady-rest.*—Each lathe is to be provided with a heavy steady-rest of approved design, fitted with five forged-steel jaws, whose inner ends are provided with concave brass caps. Steady-rest must be provided with opening to take in diameters ranging from 20 to 42 inches. This may be accomplished by fitting an internal ring into steady-rest and providing a set of extra-long chuck-jaws. The steady-rest must be made in halves, the top to be provided with a strong eye-bolt for lifting it off. The inner bore for the reception of reducing rings must be made in place.

*Taper attachment.*—For turning tapers a strong and substantial taper attachment is to be provided. This attachment is to be adjustable to any position along the bed of lathe to suit the position of carriage, and must be of length sufficient to allow of turning tapers 8 feet long at one setting.

*Boring apparatus.*—Consists in the main of a boring-bar and its carriage. Boring carriage to be easily movable on bed by power, and to be brought up to face-plate as closely as possible. It must have ample length to bore 16 feet, allowing a distance of 3 feet between work and front end of boring-bar for the boring-head, etc.

Power for all operations, as slow (for boring) and fast feed for adjusting and withdrawing bar in both directions must be conveyed from headstock, as belt-power can not be applied at the rear end of lathe. The boring-bar is to be made hollow, of hard cast iron, as specified for headstock spindle. It is to have a diameter of 11½ inches, metal to be 1½ inches thick. It is to be supported in three bearings, one at front end, one forming a middle support with drag-hook, and one at the rear end, and containing the feed-nut. The boring feed-screw to be below the boring-bar, and to have a diameter of 4 inches with pitch of thread 2 inches double.

Shifters to regulate operations of boring-bar to be conveniently located at front end of boring-bar carriage, and to be so arranged that no two operations can be engaged at the same time. Provisions to be made to throw a jet of oil in front of tool during boring; oil-tube for this purpose to pass through the interior of bar. Front end of boring-bar to be provided with a taper-hole (taper 1 in 20) and a flat key-hole for securing the boring-head to the bar. A center-head or bushing to be provided to fit to front end of boring-bar, and to have a steel center of same description as specified for headstock spindle.

All necessary countershafts, pulleys, wrenches, and other equipments to complete lathe ready for running must be furnished by the contractor.

All speeds to be arranged for steel only, viz: 12 to 20 feet per minute. Face-plate speeds to include ½, ¾, 1, 1¼, 1½, 2, 2½, 3, 3½, and 4 revolutions per minute.

Material and workmanship must be first class throughout. All shafts and feed-screws must be of steel, and all bolts of steel or refined iron. All nuts frequently used must be casehardened.

Automatic releases or breaking-pins must be provided in the carriage and boring-bar feeds.

# APPENDIX 33.

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## *SPECIFICATIONS FOR MACHINE TOOLS REQUIRED FOR THE EQUIPMENT OF SOUTH WING OF ARMY GUN FACTORY AT WATERVLIET ARSENAL, WEST TROY, N. Y.*

### SPECIFICATIONS FOR MACHINE TOOLS.

The following specifications comprise a series of machine tools required for the equipment of the south wing of Army Gun Factory at the Watervliet Arsenal, West Troy, N. Y.

The machine tools are divided into classes as follows:

Class A. 72-inch lathe for turning and boring hoops.
Class B. 60-inch lathes for turning and boring hoops.
Class C. 48-inch lathes for turning and boring hoops.
Class D. Cylinder boring machines for boring A and B hoops.
Class E. Cylinder boring machines for boring C hoops.
Class F. 72-inch vertical turning and boring mill, extra heavy, for hoops.
Class G. 36-inch lathes.
Class H. 30-inch lathes.
Class I. 22-inch lathes.
Class J. 16-inch lathes.
Class K. 26-inch slotter.
Class L. 12-inch slotter.
Class M. 38 and 44 inch planers.
Class $M_1$. 72-inch planer.
Class N. 26-inch shaping machines.
Class O. 18-inch shaping machines.
Class P. Universal radial drilling machine.
Class R. Vertical drills; 24 and 36 inches.
Class $R_1$. Vertical drill, 50-inch.
Class S. Horizontal boring and drilling machine.
Class T. Vertical milling machine, heavy.
Class U. Universal milling machine, Brown & Sharpe's.
Class $U_1$. Vertical milling machine, Brown & Sharpe's.
Class V. Universal milling machines, heavy, Pedrick & Ayer's.
Class W. Profiling machine.
Class X. Drill-grinding machine, Seller's.
Class Y. Emery-wheel grinder.
Class Z. Screw machine.

### GENERAL SPECIFICATIONS FOR CLASSES A TO Z, INCLUSIVE.

Bids will be considered for each class separately. Bidders to make two bids: one for the machine tools, delivered f. o. b., Watervliet Arsenal, West Troy, N. Y., and the other bid for delivery and erection in place, ready for operation in the new gun factory at the said arsenal. No belting is to be furnished. Bidders will furnish complete and exhaustive descriptions of their machines, accompanied by scale drawings, showing clearly all principal dimensions, and bids not accompanied by such drawings will not be considered. If desired, such drawings will be treated as confidential and returned to the bidder. Photographs may accompany such drawings, but photographs or cuts of machines only can not be considered sufficient to permit the merits of the tools to be determined. Exception as to drawings will be made for such tools as are designated by the name of the manufacturer in specifications. Approximate weight of machines will be stated.

*Bidders will state time of delivery.*

For any delay in the completion of the machines beyond the date specified in the contract there will be deducted, in the discretion of the Chief of Ordnance, from the contract price the sum of twenty dollars ($20) for each and every day (excepting Sundays) after said date, until the completion of the contract.

Bids will be considered only for machine tools manufactured in the United States.

Contract will also provide that if any doubts or disputes arise as to the meaning of anything in it or any of the papers attached to it and forming part thereof, the matter shall be at once referred to the Chief of Ordnance, United States Army, for determination, and the contractor shall abide his decision. If, however, the contractor shall feel aggrieved at any decision of the Chief of Ordnance, he shall have the right to submit the same to the Secretary of War, and his decision shall be final.

NOTE.—If any reliable manufacturer or bidder can show to the satisfaction of the Department that the machines upon which he bids are equal or superior to similar machines covered by these specifications, though differing therefrom in particulars which may be deemed unessential or immaterial as regards fitness for the performance of the particular work for which the said machines are intended, his bid will be received and duly considered in making the awards.

## CLASS A.

### *Specifications for one (1) 72-inch lathe for boring and turning hoops.*

The lathe is to swing 72 inches over the ways and not less than 48 inches over the carriage. Distance between centers to be 15 feet.

Driving cone to have five steps for 5-inch belt, ranging approximately from 15 to 27 inches diameter.

Lathe to be triple geared, giving fifteen changes of speed.

No pinion to have less than 22 teeth, and back gear to be double and about of the following proportions:

| | | |
|---|---|---|
| Cone pinion, 24 teeth,<br>Back gear, 84 teeth, | 1-inch pitch, 2¾ inch face, | slow train. |
| Back-gear pinion, 22 teeth,<br>Main driving gear, 66 teeth, | 1¼-inch pitch, 4-inch face, | |
| Cone pinion, 50 teeth,<br>Back gear, 60 teeth, | 1-inch pitch, 2¾-inch face, | fast train. |
| Back-gear pinion, 22 teeth,<br>Main driving gear, 66 teeth, | 1¼-inch pitch, 4-inch face, | |

Pitch of gears to be not less than given in this schedule.

Back gear to be so arranged on shaft as to be made movable by screw along the shaft and clamped in position.

Cone shaft to be geared into face plate about as follows:

Face-plate gear, 120 teeth, 1½-inch pitch, 5-inch face.

Face-plate pinion to be of steel, 20 teeth, 1½-inch pitch, 5-inch face.

All pinions of less than 30 teeth must be made of sound steel casting or forging; all other gear of strong, close-grained cast iron, having 25 per cent of cold-blast iron. All gearing must be accurately cut.

Diameter of cone and ratio of gearing may vary from the above, but power should remain same.

*Main driving spindle.*—To be of hard, close-grained cast iron, with front bearing 11 to 12 inches in diameter by 16 inches long; back bearing 7 to 8 inches diameter by 12 inches long; mixtures to contain 25 per cent of cold-blast iron.

Spindle to be fitted with steel bush in the front end to take the center, and with flange to bolt to face plate. Length of spindle in bearing to be about 4 feet 9 inches.

*Face plate.*—To be furnished with slots for clamping work, and fitted with four steel chuck jaws, set up by strong screws, so arranged as to clamp from the outside or the inside of hoops. Chuck jaws must be finished to one diameter in place, to have diamond point pattern face, and to be hardened. Face-plate gear to be made a separate casting and bolted to face plate. Spindle bearings to be made in halves and capped, to have strong flanges on the ends, and to be made of close-grained hard iron, as specified for spindle.

*Centers.*—To be made of steel, hardened, and at least 3¼ inches in diameter, with points made to inclose an angle of 60 degrees.

*Feeds.*—All feeds to be arranged for steel. Feeds to be positive, driven by compound gearing, and ranging from $\frac{1}{40}$ inch for the finest to about ⅜ inch for the coarsest. Reversing gear for feed to be placed at the end of the headstock or in the carriage, and change gears for screw-cutting are to be provided to cut threads varying by ⅛ inch and $\frac{1}{10}$ inch, and for the finest pitches of $\frac{1}{20}$ and $\frac{1}{16}$ inch and coarsest of 1 inch. Three changes of feed to be provided in headstock by clutch pin gears.

*Lead screw.*—To be of steel, 4 inches in diameter, ½-inch pitch, and splined to drive rack feed for turning. Lead screw nut must surround the screw entirely, and be operated by a cam, and not less than 10 inches long. Nut to be made of bronze.

Feed rack for carriage feed to be not less than 3-inch face and 1⅛-inch pitch. To be of steel.

Apron gears must be easily accessible for oiling.

*Carriage.*—To be at least 6 feet long, and fitted to ways on the front and back of bed, and also bearing on the inner way used for the tailstock guide. Fitted with one heavy compound rest.

*Compound rest.*—To have base not less than 20 inches wide by 30 inches long. To be provided with powerful cross feed, enabling rest to feed across entire width of face plate. Upper slide of compound rest to be provided with hand and power feed.

*Wing rest.*—To be placed on front wing of carriage for turning work the full swing of lathe.

*Bed.*—To be not less than 5 feet 4 inches in width over the top. To be fitted with three large ways, two for the carriage and the third one to guide head and tail stocks.

Bed must be so extended to the front that the line of strain when turning the full diameter of swing will fall inside the front way of bed. Cross girts to be box-girder form and not over 28 inches between centers. Depth of bed to be not less than 24 inches.

*Tailstock.*—To have bearing on bed not less than 38 inches long by 42 inches wide. Tailstock top to be arranged with convenient set-over, and held down by four strong bolts, and in addition to have strong pawl dropping into ratchet on bed, giving a positive resistance to thrust. Tailstock spindle to be of steel forging 6½ inches diameter. Top of tailstock to be capped or otherwise arranged that tail spindle can be removed and boring bar put in its place. Tailstock to be provided with four rollers arranged to lift tailstock slightly off the bed and enable its easy and rapid moving on the bed.

*Steady rest.*—To hold the outer ends of hoops while being bored, a strong steady rest, of approved design, must be provided. Rest to have removable top and fitted with five steel jaws, adjustable by screws from behind, and faced with brass facings on the inner ends. Section of jaws to be not less than 5 by 2½ inches. Three jaws to be placed in lower half of rest and two in upper half. Jaws to be accurately fitted to rest, and to be adjustable for diameters from 48 to 40 inches. Inner diameter of rest to be bored out in place for the reception of reducing rings. Steady rest to have bearing on bed not less than 18 inches long.

The material and workmanship must be first class throughout. All gearing must be accurately cut. All shafts and feed screws to be of steel, and all bolts of steel or refined iron, and all nuts frequently used shall be casehardened.

All necessary countershafts, pulleys, wrenches, and other appliances to complete lathe ready for operation must be furnished.

Speed of countershaft to be such as to give cutting speeds of from 12 to 20 feet per minute.

*Taper attachment.*—To turn the taper on the outside of hoops, a taper attachment of extra strength and great accuracy must be provided. This attachment must give tapers up to 1 inch to the foot in the diameter of the piece turned, and must be adjustable on the bed, and of length to turn a continuous taper 7 feet long.

### HOOP-BORING ATTACHMENTS.

A hoop-boring arrangement of the following general description is to be furnished with the lathe, and detailed drawings of it are to be submitted by the bidder.

*Boring bar in tailstock.*—The top of tailstock must be made removable, to be replaced by boring-bar bearing bolted to top of tailstock base. The boring bar to bore hoops ranging from 32 to 40 inches internal diameter and of a greatest length of 6 feet 8 inches.

*Boring bar.*—To be of sound steel forging, not less than 8 inches in diameter, to extend through the hoop into a steadying bush bolted to the front of face plate. Boring bar to be provided with suitable mechanism for quickly withdrawing from the work. Boring bar to be accurately fitted to its bearing in the tailstock base, the bearing to be arranged to clamp the bar.

*Boring head.*—A traveling boring head, fitted to the bar, to be provided and fitted with rings of suitable sizes to bore diameters ranging from 32 to 40 inches. Boring head to be provided with feed nut engaging with feed screw placed in the bar.

*Feed to boring head.*—The feed to boring head to be driven by suitable mechanism, receiving motion from feed gearing in headstock and transmitting same to feed screw in boring bar. Range of feed to be the same as for carriage feeds, viz, $\frac{1}{40}$-inch for the finest to ¼-inch for the coarsest.

*Steady bush.*—The steadying bush in the face plate to be bolted to front of same; to be fitted into grooved recess of it, and to be readily removable; to be fitted with a bronze lining, the bearing in bush to be equal to the diameter of bar and not less than 8 inches long.

## CLASS B.

### *Specifications for three (3) 60-inch lathes for turning and boring hoops.*

The lathe is to swing 60 inches over the ways and 48 inches over the carriage. One lathe is to take 15 feet and two are to take 12 feet between centers.

*Driving cone.*—To have five steps for 4½-inch belt, diameter of smallest step to be not less than 15 inches. Lathe to be triple geared, giving 15 changes of speed.

*Back gear.*—To be double, of approximately the following proportions:

<table>
<tr><td>Cone pinion, 24 teeth,</td><td rowspan="2">¾-inch pitch, 3-inch face,</td><td rowspan="4">slow train.</td><td rowspan="2"></td></tr>
<tr><td>Back gear, 84 teeth,</td></tr>
<tr><td>Back-gear pinion, 20 teeth,</td><td rowspan="2">1-inch pitch, 4-inch face,</td><td rowspan="4">fast train.</td></tr>
<tr><td>Driving gear, 70 teeth,</td></tr>
<tr><td>Cone pinion, 60 teeth,</td><td rowspan="2">¾-inch pitch, 3-inch face,</td><td rowspan="2"></td></tr>
<tr><td>Back gear, 60 teeth,</td></tr>
</table>

Pitch of gears to be not less than given in this schedule. Back gears to be movable by screw along their shaft and clamped in position.

Face-plate gear to have about 120 teeth, 1½-inch pitch, 4½-inch face; face-plate pinion to be of forged steel.

Diameter of cone and ratio of gearing may vary from the above, but power should be same.

*Spindle.*—To be made of close-grained hard cast-iron, containing at least 25 per cent of cold-blast iron. Front bearing 10 inches diameter by 14 inches long, back bearing 7 inches diameter by 10 inches long. Spindle to be driven into face plate and provided with steel bush for center. Length of spindle in bearings to be not less than 54 inches.

*Spindle bearings.*—To be made in halves and capped. To have heavy flanges on the ends, and made of hard close-grained cast-iron, same as specified for spindle.

*Face plate.*—To be driven on and bolted to the spindle. To be 60 inches diameter. To have slots for clamping work, and provided with four adjustable steel jaws of large proportions, arranged to be set up by set screws from the back. Chuck jaws to be arranged to be used either on the inner or outer side of hoops. They are to be turned to one diameter in place and hardened, and to have diamond pattern face. Face-plate gear to be made a separate casting and bolted to face-plate.

*Centers.*—To be made of steel, 3 inches diameter, hardened, and pointed to inclose an angle of 60 degrees.

*Feeds.*—To be positive, driven by compound gearing from headstock. Feed gears to give range of feed from $\frac{1}{40}$ inch for the finest to ¼ inch for the coarsest. Three changes of feed to be provided in headstock by clutch-pin gears.

Change gears for screw-cutting must be provided for changing pitches by $\frac{1}{16}$ and ⅛ inch, and for cutting screw threads ranging from $\frac{1}{20}$ to $\frac{1}{16}$ inch for the finest to 1 inch for the coarsest.

*Material for gearing.*—All pinions of less than 30 teeth to be made of sound steel casting or forging. All other gears to be of close-grained cast-iron, containing 25 per cent of cold-blast iron. All gearing throughout to be accurately cut.

*Lead screws.*—To be of steel 3 inches diameter and ½ inch pitch; to be fitted with lead-screw nut, operated by cam, and not less than 9 inches long, and to be made of bronze.

Feed rack for carriage feed to be not less than 3 inches face and ¾ inch pitch. To be of steel.

Apron gears and bearings for same must be easily accessible for oiling, and apron arranged with reversing gear for the carriage feed, and mechanism must be provided for preventing rack feed and lead-screw nut from being thrown into gear at the same time.

*Carriage.*—To be not less than 5 feet long, and fitted to ways in the front and back of bed, and bearing on the inner way used for the tailstock guide. Carriage to be fitted with one heavy compound tool rest.

*Compound rest.*—To have base not less than 18 inches wide by 24 inches long. To be provided with power cross feed for heavy work. Power feed to be provided for the upper slide of rest.

*Wing rest.*—To be placed on front wing of carriage, for turning work the full swing of lathe.

*Bed.*—To be not less that 48 inches wide and fitted with three ways, two for the carriage and one to guide the tailstock. Bed must be well extended to the front to give support to the carriage, so that the line of strain, when turning the full diameter of swing, will fall inside the front way of bed. Cross girts must be of box-girder form and 24 inches between centers. Depth of bed to be not less than 20 inches.

*Tailstock.*—To have a bearing on the bed 40 inches long by about 32 inches wide. Tailstock to be provided with convenient set-over and held down by four strong bolts. In addition, tailstock base is to be provided with a strong pawl, dropping into ratchet in bed, giving a positive resistance to thrust. Tail spindle to be of steel, 6½ inches diameter. Top of tailstock to be capped, or otherwise arranged so that tail spindle can be removed and boring bar put in its place. Tailstock to be provided with four rollers, arranged to lift tailstock slightly off the bed and enable easy and rapid movement along the bed.

*Steady rest.*—To hold the outer ends of hoops while being bored, a strong steady rest, of approved design, must be provided. Rest to have removable top and to be fitted with five steel jaws, adjustable by screws, and faced with brass facings on the inner ends. Section of jaws to be not less than 4½ by 2½ inches. Three jaws are to be placed in the lower half and two in the upper half of steady rest, and accurately fitted in their pockets. Steady rest bearing on bed to be not less than 15 inches long, and opening in rest to take in 40 inches, and to be bored out in position for the reception of reducing rings. Jaws to be adjustable for diameters from 40 to 34 inches.

All necessary countershafts, pulleys, wrenches, and other equipments to complete lathe ready for running must be furnished.

Countershafts' speed to be arranged for a cutting speed of from 12 to 20 feet per minute.

The material and workmanship of these lathes must be first class throughout. All shafts and feed screws must be of steel, and all bolts of steel or refined iron. All nuts frequently used must be casehardened.

*Taper attachment.*—To turn the taper on the outside of hoops a taper attachment of extra strength and great accuracy must be provided. This attachment must give a range of tapers from 0 to 1 inch to the foot in the diameter of piece turned, and must be adjustable along the bed, and of length sufficient to turn a continuous taper 7 feet long.

### HOOP-BORING ATTACHMENTS.

A hoop-boring arrangement of the following general description is to be furnished with each lathe, and detailed drawings of it are to be submitted by the bidder.

*Boring bar in tailstock.*—The top of tailstock must be made removable, to be replaced by boring-bar bearing bolted to top of tailstock base. The boring bar to bore hoops ranging from 26 to 36 inches internal diameter, and having a greatest length of 6 feet 8 inches.

*Boring bar.*—To be of sound steel forging, not less than 8 inches diameter, to extend through the hoop into a steadying bush bolted to the front of face plate. Boring bar to be provided with suitable mechanism for quickly withdrawing it from the work. Boring bar to be accurately fitted to its bearing in the tailstock base, the bearing to be arranged to clamp the bar.

*Boring head.*—A traveling boring head, fitted to the bar, to be provided, and fitted with rings of suitable sizes to bore diameters ranging from 26 to 36 inches. Boring head to be provided with feed and engaging with feed screw placed in the bar.

*Feed to boring head.*—The feed to boring head to be driven by a suitable mechanism, receiving motion from feed gearing in headstock and transmitting same to feed screw in boring bar. Range of feed to be the same as for carriage feeds, viz: from $\frac{1}{40}$ inch for the finest to ¼ inch for the coarsest.

*Steadying bush.*—The steadying bush in face plate to be bolted to front of same, to be fitted into a grooved recess in it, and to be readily removable; to be fitted with a bronze lining. The bearing in bush to be about equal to diameter of bar and not less than 8 inches long.

## CLASS C.

*Specifications for three (3) 48-inch lathes for boring and turning hoops.*

The lathe is to swing 48 inches over the ways and 36 inches over the carriage, and to take 12 feet between centers.

*Driving cone.*—To have six steps for 4½-inch belt, diameter of smallest step to be not less than 8 inches.

Cone to be strongly back geared, with pinion on cone shaft driving into gear on face plate, giving 12 changes of speed.

*Back gear.*—To be about the following proportions:
Cone pinion, 26 teeth, ¾-inch pitch, 3-inch face.
Back gear, 90 teeth, ¾-inch pitch, 3-inch face.
Back-gear pinion, 20 teeth, 1-inch pitch, 4-inch face.
Cone-spur gear, 70 teeth, 1-inch pitch, 4-inch face.
Face-plate gear, 100 teeth, 1⅜-inch pitch, 5-inch face.
Face-plate pinion, 17 teeth, 1⅜-inch pitch, 5-inch face.

Diameter of cone and ratio of gearing may vary from above, but power should be same.

*Spindle.*—To be of forged steel, containing at least 0.5 per cent of carbon, with clean surfaces in bearings. Front bearing to be not less than 8 inches in diameter by 10 inches long. Pack bearing 6 inches diameter by 8 inches long. Spindle to drive into face plate and to be provided with flange to bolt to same. Length of spindle in bearings to be not less than 48 inches.

*Face plate.*—To have 48 inches diameter, to be provided with slots for clamping work, and fitted with four steel chuck jaws, set up by strong screws, so arranged as to chuck from the inside or outside of hoops. Chuck jaws must be finished to one diameter in place and hardened and to have diamond pattern face. Face-plate gear to be made a separate casting, and bolted to face plate.

*Spindle bearings.*—To be made of hard composition metal containing

85 per cent copper and 15 per cent tin. To be provided with strong flanges on the ends, made in halves and capped. Bearings must be carefully scraped to fit spindle.

*Centers.*—To be of tool steel, 3 inches diameter, hardened, with points made to inclose an angle of 60 degrees.

*Feeds.*—To be suitable for steel. All feeds to be positive, driven by compound gearing, and ranging from 1/40 inch for the finest to ¼ inch for the coarsest. Reversing gear for the feed to be placed in the carriage, and change gears for screw cutting to be provided to cut screw threads varying by ⅛ and 1/16 inch, and for finest pitches of 1/20 and 1/16 inch to the coarsest of 1 inch. Three changes of feed to be provided in headstock by clutch pin gears.

*Material for gearing.*—All driving pinions having less than 30 teeth to be made of sound steel castings or forgings, and all other gears to be made of strong close-grained cast iron, having at least 25 per cent of cold blast iron. All gearing of any kind to be accurately cut.

*Lead screw.*—To be of steel, 3 inches diameter, ½-inch pitch, and splined to drive rack feed for turning. Lead-screw nut to be operated by cam, to be not less than 8 inches long, and to be of bronze.

*Feed rack for carriage feed.*—To be not less than 2¼-inch face and ¾-inch pitch, and to be made of steel.

Apron gears and bearings for same must be easily accessible for oiling, and mechanism must be provided preventing rack feed and lead-screw nut from being thrown into gear at the same time.

*Carriage.*—To be 60 inches long, and fitted to ways on the front and back of bed, and bearing on the inner way used for the tailstock guide. Carriage to be fitted with one heavy compound rest.

*Compound rest.*—To have base not less than 15 inches wide by 22 inches long. To be provided with powerful cross feed designed for heavy work. Upper slide of compound rest to be provided with power feed.

*Wing rest.*—To be placed on front wing of carriage for turning work the full swing of lathe.

*Bed.*—To be not less than 42 inches wide; to be fitted with four ways, two for the carriage and two for the head and tail stocks. Bed must be well extended to the front to bring line of strain inside of carriage way. Cross girts to be of box-girder form, 24 inches between centers. Depth of bed to be not less than 18 inches.

*Tailstock.*—To have bearing on bed 32 inches long by 28 inches wide. Top of tailstock to be provided with convenient set-over, and held down by four strong bolts, and in addition tailstock is to be provided with a strong pawl dropping into ratchet in bed, giving a positive resistance to thrust.

Tail spindle to be of forged steel, 5½ inches diameter.

Top of tailstock to be capped or otherwise arranged so that tail spindle can be removed and boring bar put into its place.

Tailstock to be provided with suitable mechanism for moving it easily along the way.

*Steady rest.*—To hold the outer ends of hoops while being bored, a strong steady rest of approved design must be provided. Rest to have removable top and to be fitted with five steel jaws, adjustable by screws, and faced with brass facings on the inner ends. Section of jaws to be not less than 3½ by 2 inches. Three jaws to be placed in the lower half of rest and two in the upper half. Jaws to be accurately fitted to rest. Opening of rest to be bored in place on the lathe for the reception of reducing rings. Opening to take 36 inches diameter and jaws to be adjustable for diameters from 36 to 30 inches. Steady rest to have a bearing on bed not less than 12 inches long.

A reducing ring must be provided and an extra set of jaws to hold hoops from 30 to 18 inches in diameter. Steady rest to have a bearing on bed not less than 12 inches long.

All countershafts, pulleys, wrenches, and other equipment necessary to complete the lathe ready for operation must be provided. Speed of coustershaft to be suitable for a cutting speed of from 12 to 20 feet per minute. The material and workmanship must be first-class throughout. All shafts, and feed screws must be made of steel, and all bolts of steel or refined iron. All nuts frequently used to be casehardened.

*Taper attachment.*—To turn the taper on the outside of hoops a taper attachment of extra strength and great accuracy must be provided. Attachment must give tapers ranging from 0 to 1 inch per foot length. It must be made adjustable lengthwise on the bed, and of length sufficient to turn a continuous taper 6 feet long.

### HOOP-BORING ATTACHMENTS.

A hoop-boring arrangement of the following general description is to be furnished with each lathe, and detailed drawings of it are to be submitted by the bidder.

*Boring bar in tailstock.*—The top of tailstock must be made removable, to be replaced by boring bar bearing bolted to top of tailstock base. The boring bar is to bore hoops ranging from 17 to 27½ inches internal diameter, and having a greatest length of 63 inches.

*Boring bar.*—To be of sound steel forging, not less than 8 inches in diameter, to extend through hoop into a steadying bush bolted to the front face plate. Boring bar to be provided with a suitable mechanism for quickly withdrawing it from the work. Boring bar to be accurately fitted to its bearing in the tailstock base, the bearing to be arranged to clamp the bar.

*Boring head.*—A traveling boring head, fitted to the bar, to be provided, and fitted with rings of suitable sizes to bore diameters ranging from 17 to 27½ inches. Boring head to be provided with feed nut engaging with feed screw placed in the bar.

*Feed to boring head.*—The feed to boring head to be driven by suitable mechanism, receiving motion from feed gearing in headstock, and transmitting same to feed screw in boring bar. Range of feed to be the same as for carriage feeds, viz: From $\frac{1}{40}$ inch for the finest to ¼ inch for the coarsest.

*Steadying bush.*—The steadying bush in face plate to be bolted to front of same, to be fitted into a grooved recess in it, and to be readily removable; to be fitted with a bronze lining, the bearing in bush to be about equal to diameter of bar, and not less than 8 inches long.

## CLASS D.

### *Specification for two (2) cylinder-boring machines for 12-inch A and B hoops.*

These machines will be used for boring hoops ranging in diameter from 26 inches to 40 inches (internal) and in length from 40 to 80 inches; largest outside diameter of hoops, 48 inches. Machine to consist of bed, upon which are mounted the driving head, back head, and carriages. Distance from center of boring bar to top of carriage to be about 28 inches.

*Driving gear.*—Boring bar to be driven by either tangent or spur gearing, transmitting power from 4-step cone for 5-inch belt, cone steps ranging from about 18 inches to 26 inches in diameter. Cone to be geared to bar in ratio of not less than 40 to 1.

Diameter of cone and ratio of gearing may be changed from above, but power must not be any less.

*Headstock.*—To be bolted to top of bed; to be about 30 inches long, and to carry on its outer end the driving gear. Headstock to be fitted with sleeve driving the bar from the gearing. Sleeve to run in composition bearings of 90 parts copper and 10 parts tin. Bearings to be in halves, not less than 10 inches long and capped. Driving sleeve and gearing to be made of strong, close-grained iron, containing 25 per cent of cold-blast iron.

*Boring bar.*—To be of open-hearth steel; to be 10 inches in diameter, and provided with two splines on opposite sides 1⅛ inches wide by 11/16 inch deep. Driving feathers to be firmly fastened in sleeve which drives bar, and to be not less than 10 inches long.

*Back head.*—To be of same length as headstock; to be fitted to and adjustable on the bed for different lengths of hoops. Back head to be provided with cast-iron sleeve, flanged at each end, made of close-grained iron, and feathered to bar to revolve with it. Sleeve to run in composition bearings composed of 90 parts of copper and 10 parts of tin. Bearings to be in halves not less than 10 inches long and capped. Back head to be in perfect alignment with driving head.

*Feed.*—To be by rack and pinion, operating on the boring bar. Both to be of steel, ¾-inch pitch, 3-inch face. Pinion to have not less than 15 teeth. Feed rack to be attached to outer end of bar and well provided with antifriction washers to take up thrust. Four changes of feed to be provided, ranging from 1/40 inch to ⅛ inch, reversible in either direction. Bar to feed 6 feet 9 inches at one setting, and feed rack to be arranged to allow bar being drawn by hand across the opening between the two heads. Feed mechanism and guide for feed rack to be attached to back head.

*Carriages.*—To be two in number, each about 18 inches long, movable on the bed and provided with bolts for bolting to bed. Bolts to be easily accessible without removing back rest. Upper surfaces to be well provided with slots to receive two steady rests.

*Steady rests.*—To be two in number, with removable top. Lower half to be arranged to bolt to carriage, and provided with two adjustable bearings for holding hoops, ranging from 32 to 48 inches in diameter. Steady-rest top to clamp to hoops and bear on same in at least two places.

*Bed.*—To be approximately 14½ feet long by 38 inches wide, not less than 16 inches deep, with top provided with T-slots for holding carriages. Sides of bed to be joined by double-webbed girders, about 24 inches between centers. Top and bottom flanges to be not less than 6 inches wide, and metal in sides 1½ inches thick.

*Boring heads.*—Boring heads to be clamped to bar, and to be provided with driving feathers and fitted with four adjustable tools each; must be provided to bore out or enlarge the following rough diameters, viz, 25½, 26½, 32½, and 38½ inches. Hubs of boring heads to be not less than 13 inches long.

*Facing heads.*—For facing ends of cylinders two facing heads must be provided. These are to be fitted and clamped to the inner end of the sleeves revolving in the driving and back heads and surrounding the boring bar. They must be provided with adjustable tools and must have a range to face from a maximum diameter of 48 inches to a minimum diameter of 24 inches. Tool holder to have 6 inches travel parallel to axis of boring bar. Facing heads must be readily removable from the sleeves carrying them.

*Workmanship and material.*—To be first-class throughout. All shafts not otherwise specified to be of good machinery steel; all bolts to be of steel or refined iron; all nuts frequently used to be casehardened.

Countershafts, pulleys, hangers, wrenches, and all other appliances to complete machine ready for operation to be furnished with machine. Accuracy of machine must be guaranteed.

## CLASS E.

### *Specifications for two (2) cylinder-boring machines for 12-inch C hoops.*

These machines will be used for boring hoops ranging in internal diameter from 16 to 22 inches, and in length from 40 to 80 inches; largest outside diameter to be 30 inches. Machine to consist of bed upon which are mounted the driving head, back head, and carriage. Distance from center of boring bar to top of carriages to be about 20 inches.

*Driving gear.*—Boring bar to be driven by either tangent or spur gearing, transmitting power from 4-step cone, for 3½-inch belt, cone steps ranging from about 20 to 14 inches diameter, and geared to bar in ratio of not less than 40 to 1.

Diameter of cone and ratio of gearing may vary from above, but power must be the same.

*Headstock.*—To be bolted to top of bed; to be about 24 inches long and carrying on its outer end the driving gear. Headstock to be fitted with sleeve driving the bar from the gear. Sleeve to run in composition bearings of 90 parts copper and 10 parts tin. Bearings to be in halves not less than 10 inches long and capped. Driving sleeve and gearing to be made of strong, close-grained iron, containing 25 per cent of cold-blast iron.

*Boring bar.*—To be of open-hearth steel. To be 7¾ inches in diameter. and provided with two splines on opposite sides ⅞-inch wide by ½-inch deep. Driving feathers to be firmly fastened in the sleeve which drives bar, and to be not less than 8 inches long.

*Back head.*—To be of same length as head stock; to be fitted to and adjustable on the bed for different lengths of hoops. Back head to be provided with cast-iron sleeve, flanged at each end, made of close-grained iron, and feathered to bar to revolve with it. Sleeve to run in composition bearings composed of 90 parts of copper and 10 parts of tin. Bearings to be in halves not less than 10 inches long and capped. Back head to be in perfect alignment with driving head.

*Feed.*—To be by rack and pinion, operating on the boring bar. Feed rack and pinion to be of steel, to have not less than ⅝-inch pitch and 3-inch face, and pinion to have not less than 15 teeth. Feed rack to be attached to outer end of bar and well provided with anti-friction washers to take up thrust. Four changes of feed to be provided, ranging from $\frac{1}{40}$ inch to ⅛ inch, reversible in either direction. Bar to feed 6 feet 9 inches at one setting, and feed rack to be arranged to allow bar being drawn by hand across the opening between the two heads. Feed mechanism and guide for feed rack to be attached to back head.

*Carriages.*—To be two in number; to be about 18 inches long, movable on the bed, and bolted to it. Bolts to be readily accessible without removing back rest. Upper surfaces to be provided with slots to receive two steady rests.

*Steady rests.*—To be two in number, with removable top. Lower half to be arranged to bolt to carriage and provided with two adjustable bearings or jaws for holding hoops ranging from 18 to 30 inches diameter. Steady-rest top to clamp hoops and bear on same in at least two places.

*Bed.*—To be approximately 13½ feet long by 27 inches wide and not less than 12 inches deep, with top provided with T-slots for holding carriage. Sides of bed to be joined by double-webbed girders, about 24 inches between centers. Top and bottom flanges to be not less than 6 inches wide, and metal in sides to be 1¼ inches thick.

*Boring heads.*—Boring heads to be clamped to bar, and to be provided with driving feathers and fitted with four adjustable tools each, must be provided to bore out or enlarge the following rough diameters, viz, 16, 17, 18, 19, 20, 21, and 22 inches. Hubs of boring heads to be not less than 10 inches long.

*Facing heads.*—For facing ends of hoops two facing heads must be provided. These to be fitted and clamped to the inner ends of the sleeves revolving in the driving and back heads and surrounding the boring bar. Facing heads must have a range to face from a maximum diameter of 30½ inches to a minimum diameter of 16 inches. Tools to have an adjustment of 6 inches in the direction of axis of boring bar. Facing heads must be readily removable from the sleeves carrying them.

*Workmanship and material.*—To be first class throughout. All shafts not otherwise specified must be of good machinery steel. All bolts to be of steel or refined iron; all nuts frequently used to be casehardened.

Countershafts, pulleys, hangers, wrenches, and all other appliances to complete machine ready for operation must be furnished with the machine.

Accuracy of machine must be guaranteed.

## CLASS F.

*Specifications for one (1) 72-inch vertical boring mill (extra heavy) for boring and turning hoops 48 inches deep; to turn 73 inches diameter and 48 inches high under tool holders.*

This machine to consist of bed not less than 20 inches deep, with table supported on circular bearing near outer circumference. Table to be driven on and bolted to a long spindle with split conical sleeve at upper end and step bearing at lower end. Step bearing to be joined to bed by a heavy cast-iron truncated cone reaching down from the bottom of bed.

*Housings.*—To be of box form, with heavy front post at least 8 inches on the face. Housings to be bolted to bed by six bolts 1¾ inches diameter, and to reach down the full depth of bed. Top of housings to be joined by a top-brace at least 22 inches deep.

*Cross rail.*—To be of box form, with arched back, completely closed. Depth of housing on face to be not less than 23 inches. Depth from face to back in center to be not less than 18 inches.

Cross rail to be fitted to front of housings and accurately scraped to give full and perfect bearing on housing faces.

*Boring heads.*—Two boring heads, each fitted with independent cross-feed screw and down-feed rod to be accurately fitted to cross rail. Each head to consist of saddle 26 inches wide, swing arranged for set-over for turning tapers. Set-over to be operated and controlled by worm gearing on the upper circular arc of saddle. Length of swing to be not less than 48 inches, and to have capped bearing at upper and lower ends for boring bar.

*Boring bars.*—To be of open-hearth steel, containing one-half per cent of carbon, to be octagon in section; section to be equal to area of 8¼-inch circle. Lower ends of bars to be fitted with removable tool holders of forged steel, so arranged that tools can be set in vertical or horizontal positions on either side of bar. Vertical travel of bars to be 50 inches.

*Feeds.*—Each head to be provided with cross feed for saddle and vertical feed for bar. Feeds to be reversible and independent for each head.

Right-hand head to be fitted with opening nut on feed screw, and provided with rack pinion for rapid movement on the cross rail.

Feed to be driven by friction disk, and quickly adjustable to any degree from $\frac{1}{40}$ to ¼ inch.

*Counterweight.*—Bars to be counterbalanced by one weight common to both bars. Chain and sheaves for counterweight to be arranged to always pull in a direction parallel with the axis of bar.

*Table.*—To have diameter of 70 inches, and to be not less than 5 inches deep on outer rim.

To be provided with T-slots for holding work, and, in addition, to have four hardened steel chuck jaws, with diamond-point faces, adjustable to any diameter and arranged for inside or outside chucking, and to be readily removable, leaving the table clear for other work.

*Spindle.*—To be 11 inches diameter at upper end, with upper bearing not less than 11 by 16 inches long, fitted in split conical bush for taking up wear. Lower spindle bearing to be not less than 6 inches diameter by 10 inches long. Length of spindle under table to be not less than 50 inches. Spindle and bushes to be made of strong close-grained cast iron containing 25 per cent of cold-blast iron. Lower spindle step to be provided with wedge for raising table off the outer bearing.

*Driving gear.*—Table is to be driven by cone pulley placed in the left-hand side of bed and transmitting motion to table by means of horizontal shaft, bevel gears, vertical shaft, and circular gear and pinion under table.

*Table rack gear.*—To have about 120 teeth and not less than 1⅜-inch pitch and 6-inch face. To be accurately cut from the solid. Gear to be bolted to the bottom of table.

*Driving pinion.*—To be of forged steel and to have not less than 20 teeth, 1⅜-inch pitch and 6-inch face.

*Driving cone.*—To have six steps for 4-inch belt, ranging about from 12 to 26 inches diameter. Cone to be back geared approximately as follows:

Cone pinion, 25 teeth, ¾ P.
Back gear, 100 teeth, ¾ P.
Back-gear pinion, 20 teeth, 1 P.
Cone spur, 80 teeth, 1 P.

Bevel gears to have about 25 and 35 teeth, respectively, and not less than 1¾-inch pitch and 5-inch face, giving 12 changes of speed.

Ratio of cone to table to be about 130 revolutions of cone to one revolution of table.

### SPECIAL BORING BAR AND STEADY REST.

For boring hoops having a height of 48 inches, a special boring bar and steady rest are to be provided.

The boring bar to be made of open-hearth steel, and not less than 9 inches in diameter. Lower end of bar to be fitted to step in the table.

Step to be provided with conical adjustment to take up wear. Upper end of bar to be held in a saddle fitted to the front of cross rail. Bar to be counterweighted and provided with rack and pinion for quickly withdrawing from the work.

A traveling boring head to be provided and accurately fitted to bar. Head to be arranged for four adjustable cutters, and to be furnished with rings suitable for boring all diameters ranging from 32 to 40 inches. Boring head to be provided with feed nut engaging with feed screw inserted in boring bar.

The feed for the boring head is to be driven by suitable mechanism, transmitting motion from the feed works of the mill. Range of feeds to be $\frac{1}{40}$ inch for the finest to $\frac{1}{4}$ inch for the coarsest.

For steadying the upper ends of 'hoops a strong and substantial steady rest must be provided. Steady rest to be arranged to clear the work when putting the same on the mill. To be fitted with five steel jaws adjustable by screws and faced with brass facings on the inner ends.- Section of jaws to be not less than 4½ by 2¼ inches. Jaws to be adjustable for diameters ranging from 48 to 38 inches.

*Material.*—Driving shafts to be of open-hearth steel containing ½ per cent of carbon. Shafts to run in bronze bushes containing 90 per cent of copper and 10 per cent tin. All other shafts and all feed screws to be of good machinery steel. All bolts to be of refined iron, and all nuts frequently used to be casehardened.

*Gearing.*—All the gearing to be made of strong close-grained iron containing not less than 25 per cent of cold-blast iron, unless otherwise specified. All pinions having less than 30 teeth to be of forged steel.

Workmanship and material to be first class throughout.

All working parts to be accurately fitted, and all bearing surfaces to be accurately scraped to perfect bearings.

All countershafts, hangers, pulleys, wrenches, and other appliances to complete machine ready for operation are to be furnished with mill. Foundation plans to be furnished.

## CLASS G.

### SPECIFICATIONS FOR FOUR (4) 36-INCH LATHES.

Lathe to swing 36 inches over the ways and 26 inches over carriage, and to take 10 feet between centers.

*Driving cone.*—To have five steps for 4-inch belt, smallest step not less than 8 inches diameter. Cone to run on spindle and geared by back gear to spindle and by triple gear to face plate. Gearing to be approximately as follows:

| | |
|---|---|
| Cone pinion, 24 teeth, ¾ inch pitch, | 2½ inch face. |
| Back gear, 88 feet, ¾ inch pitch, | |
| Back-gear pinion, 22 teeth, 1-inch pitch, | 3½ inch face. |
| Cone-spur gear, 66 teeth, 1-inch pitch, | |
| Face-plate pinion, 14 teeth, 1-inch pitch, | 4½-inch face. |
| Face-plate gear, 70 teeth, 1-inch pitch, | |

giving 15 changes of speed.

Ratio of gearing may vary from the above, but power must remain same.

*Spindle.*—To be made of open-hearth steel containing not less than one-half per cent of carbon. Front bearing to be not less than 6 inches diameter by 9 inches long. Back bearing to be not less than 4 inches diameter by 6 inches long. Length of spindle in bearings to be not less than 48 inches.

*Spindle bearings.*—To be made of hard bronze containing 85 per cent of copper and 15 per cent of tin. Bearings to have flanges at the ends, and to be carefully scraped to a true bearing on spindle. To be capped.

*Face plate.*—To be 36 inches in diameter, provided with slots for clamping work, and to be forced on spindle and firmly keyed. Face-plate gear to be a separate casting and bolted to face plate.

*Centers.*—To be of good tool steel, $2\frac{1}{2}$ inches diameter, hardened, and pointed to inclose an angle of 60 degrees.

*Feeds.*—To be suitable for steel and to be positive, driven by gearing from headstock. To range from $\frac{1}{40}$ inch for the finest to $\frac{1}{10}$ inch for the coarsest. Reversing gear for feed to be placed in the carriage, and change gear is to be provided for cutting screw threads varying by $\frac{1}{8}$ and $\frac{1}{10}$ inch, and ranging from $\frac{1}{20}$ and $\frac{1}{16}$ inch for the finest to 1 inch for the coarsest. Three changes of feed to be provided in headstock by clutch-pin gears.

*Material for gearing.*—All driving pinions having less than 30 teeth are to be made of steel forging or casting, and all other gears are to be made of strong close-grained cast-iron containing 25 per cent of cold-blast iron. All gearing to be accurately cut.

*Lead screw.*—To be of steel, $2\frac{1}{2}$ inches diameter, $\frac{1}{4}$-inch pitch. Lead-screw nut to be operated by cam and to be not less than 7 inches in length.

*Feed rack.*—To be not less than 2 inches wide and $\frac{5}{8}$-inch pitch, and to be of steel.

*Carriage.*—To be at least 48 inches long; to be fitted to ways on front and back, and bear on the inner way used for tailstock guide. To be fitted with one heavy compound rest.

*Compound rest.*—To have base at least 10 inches wide by 16 inches long; to be provided with power cross feed designed for heavy work. Wing rest for turning full swing over ways, to be fitted to front wing of carriage.

*Bed.*—To be not less than 30 inches wide. To be provided with four ways, two for carriage and two for head and tail stocks. Cross girts (box-girder form preferred) to be spaced 24 inches between centers. Depth of bed to be not less than 18 inches.

*Tailstock.*—Base to be 20 inches long and 20 inches wide. To be held to bed by four heavy bolts. Top to be provided with convenient set-over. Tail spindle to be of steel, 4 inches in diameter.

All necessary countershafts, pulleys, wrenches, steady rest, and other appliances to complete lathe ready for operations to be furnished. Friction-clutch pulleys for open and crossed belt.

The workmanship must be first-class throughout. All shafts and feed screws must be of steel, and all bolts of steel or refined iron. All nuts frequently used must be casehardened.

## CLASS H.

### *Specifications for one (1) 30-inch swing engine lathe.*

Lathe to swing not less than 30 inches over ways, and not less than 20 inches over carriage, and to take 8 feet between centers.

*Driving cone.*—To have not less than five steps for 4-inch belt, smallest step to be not less than 7 inches diameter. To be geared to a spindle in a ratio of not less than 12 to 1, giving not less than ten changes of speed.

*Spindle.*—To be of open-hearth steel, containing not less than one-half per cent of carbon. Front bearings to be 5 inches diameter and at least 6 inches long; back bearing 2½ inches diameter by at least 4 inches long.

*Spindle bearings.*—To be made of best hard composition, containing 85 per cent copper and 15 per cent tin. Bearings must be carefully scraped to fit spindle.

*Feeds.*—To be positive, and driven from the spindle. To range from $\frac{1}{40}$ inch for the finest to ⅛ inch for the coarsest. Two changes by clutch pin to be provided in headstock.

*Face plate.*—To be 30 inches diameter and screwed to front end of spindle.

*Spindle centers.*—To be of good tool steel, 2 inches diameter, hardened, and pointed to inclose an angle of 60 degrees.

*Compound gearing.*—To be provided for cutting screw threads varying by ⅛ inch and $\frac{1}{10}$ inch, and ranging $\frac{1}{20}$ and $\frac{1}{16}$ inch for the finest to ⅜ inch for the coarsest, respectively.

*Gearing.*—All gearing, of whatever description, is to be accurately cut, and to be made of steel or strong close-grained iron containing 25 per cent of cold-blast iron.

*Lead screw.*—To be of steel, 2¼ inches diameter, ¼-inch pitch. Lead-screw not to be operated by cam, and to be not less than 7 inches in length.

*Feed rack.*—To be not less than 2 inches wide and ⅝-inch pitch.

*Carriage.*—To have length not less than 42 inches, to be fitted to ways on front and back of bed, and bear on the inner way used for tailstock guide. To be fitted with one heavy compound rest.

*Apron.*—To be fitted with feed gear for longitudinal feed to carriage, and cross feed to compound rest, and lead-screw nut for screw cutting. Reversing gear for longitudinal and cross feeds to be placed in apron, and safety stop is to be provided to prevent feed gear and lead-screw nut from being in operation at the same time.

*Compound rest.*—To have base at least 10 inches wide by 18 inches long. To be provided with power cross feed designed for heavy work.

Wing rest for turning full swing overways to be fitted to front wing of carriage.

*Bed.*—To be not less than 27 inches wide. To be provided with four ways, two for carriage and two for head and tail stocks.

Cross girts (of box-girder form preferred) to be spaced 24 inches between centers. Depth of bed to be not less than 15 inches.

*Tailstock.*—To have base at least 20 inches long and 18 inches wide. To be held to bed by two heavy bolts. Top to be provided with convenient set-over. Tail spindle to be of steel, not less than 3¼ inches diameter.

All necessary countershafts, pulleys, wrenches, steady rest, and other appliances to complete lathe ready for operation to be furnished with lathe.

Friction-clutch pulleys to be provided for cross and open belt.

The workmanship must be first-class throughout. All shafts and feed screws must be of steel, and all bolts of steel or refined iron.

All nuts frequently used must be casehardened.

Approximate weight of machine will be stated.

## CLASS I.

### *Specifications for four (4) 22-inch lathes.*

Lathe to swing 22 inches over the ways and 15 inches over the carriage, and to take 7 feet between the centers.

*Driving cone.*—To have four steps for 3-inch belt, smallest step to be not less than 6 inches in diameter, and geared to spindle in ratio of about 10 to 1, giving eight changes of speed.

*Spindle.*—To be made of open-hearth steel, containing not less than ½ per cent of carbon. Front bearing to be 3½ inches diameter by about 5 inches long. Back bearing to be not less than 2¼ inches diameter and 3½ inches long. Length of spindle in bearings to be from 28 to 30 inches. Hole through full length of spindle 1½ inches.

*Spindle bearing.*—To be made of hard bronze, containing 85 per cent of copper and 15 per cent of tin. Bearings to have heavy flanges at the ends, and to be carefully scraped to fit spindle.

*Face plate.*—To be 22 inches diameter and screwed to front end of spindle.

*Centers.*—To be of good steel, 1$\frac{5}{16}$ inches diameter, hardened, and pointed to inclose an angle of 60 degrees.

*Feeds.*—To be by gearing or belt on step cone driven from spindle. with two changes by clutch pin provided in headstock, making four changes of feed. Feeds to range from $\frac{1}{40}$ inch for the finest to $\frac{1}{16}$ inch for the coarsest.

*Compound gearing.*—To be provided for cutting screw threads varying by ⅛ to $\frac{1}{10}$ inch, and ranging from $\frac{1}{20}$ to $\frac{1}{16}$ inch for the finest to $\frac{1}{10}$ and ⅜ inch for the coarsest, respectively.

*Material for gearing.*—All gearing of whatever description is to be accurately cut, and made of steel or close-grained iron containing 25 per cent of cold-blast iron.

*Lead screw.*—To be of steel, 1⅝ inches diameter, ¼-inch pitch. Lead-screw nut to be operated by cam, and to be not less than 5 to 6 inches in length.

*Carriage.*—To be 28 inches long. To be fitted to ways on front and back of bed, and bear on the same way used for tailstock guide. To be fitted with one heavy compound rest.

*Apron.*—To be fitted with gear for longitudinal feed to carriage and cross feed to compound rest, and lead-screw nut for screw cutting. Reversing gear for feeds to be put in apron, and safety stop to be provided to prevent feed gear and lead-screw nut from being in operation at the same time.

*Compound rest.*—To have base from 7 to 8 inches wide by 12 inches long. To be provided with power cross feed designed for heavy work. Wing rest for turning full swing over ways to be fitted to front wing of carriage.

*Bed.*—To be not less than 20 inches wide. To be provided with four ways, two for carriage and two for head and tail stocks. Sides to be joined by web across the top of bed. Depth of bed to be not less than 15 inches.

*Tailstock.*—To have base 13 to 14 inches each way. To be held to bed by two heavy bolts. Top to be provided with convenient set-over. Tail spindle to be of steel, 2⅝ inches diameter.

The workmanship must be first class throughout. All shafts and feed screws must be of steel, and all bolts of steel or refined iron. All nuts frequently used must be casehardened.

All necessary countershafts, pulleys, wrenches, steady rest, and other appliances to complete lathe ready for operation to be furnished with lathe. Friction-clutch pulleys for crossed and open belt to be provided on counter.

## Class J.

### *Specifications for two (2) 16-inch lathes.*

**(As built by the Pratt and Whitney Co. or equal.)**

Lathe to swing 16 inches over the ways and 7½ inches over the carriage, and to take 4 feet 6 inches between the centers.

*Driving cone.*—To have four steps for 2½-inch belt, smallest step to be not less than 5 inches diameter, and geared to spindle in ratio of about 10 to 1, giving eight changes of speed.

*Spindle.*—To be made of open-hearth steel. Front bearing to be 2¼ inches diameter by about 4½ inches long. Back bearing to be about 2 inches diameter and 3½ inches long. Length of spindle in bearings to be about 24 inches. Hole through full length of spindle ¾ inch.

*Spindle bearing.*—To be made of hard bronze, containing 85 per cent of copper and 15 per cent of tin. Bearings to have heavy flanges at the ends and to be carefully scraped to fit spindle.

*Face plate.*—To be screwed to front end of spindle.

*Centers.*—To be of good steel, 15/16 inch diameter, hardened, and pointed to inclose an angle of 60 degrees.

*Feeds.*—To be by gearing.

*Compound gearing.*—To be provided for cutting screw threads varying from 3 to 48 threads to the inch.

*Material for gearing.*—All gearing, of whatever description, is to be accurately cut and made of steel or strong close-grained iron.

*Lead screw.*—To be of steel 1 1/16-inches in diameter, 3/16-inch pitch.

*Carriage.*—To be 18 inches long. To be fitted to ways on front and back of bed and bear on the same way used for tailstock guide. Rest to be provided with cross feed.

*Apron.*—To be fitted with gear for longitudinal feed to carriage and cross-feed to rest, and lead-screw nut for screw-cutting. Reversing gear for feeds to be put in apron, and safety stop to be provided to prevent feed gear and lead-screw nut from being in operation at the same time.

*Tool rest.*—To be provided with power cross feed.

*Bed.*—To be not less than 14 inches wide. To be provided with four ways, two for carriage and two for head and tail stocks. Sides to be joined by web across the top of bed. Depth of bed to be not less than 9½ inches.

*Tailstock.*—To be held to bed by two heavy bolts. Top to be provided with convenient set-over. Tail spindle to be of steel.

The workmanship must be first class throughout. All shafts and feed screws must be of steel, and all bolts of steel or refined iron. All nuts frequently used must be casehardened.

All necessary countershafts, pulleys, wrenches, steady rest, and other appliances to complete lathe ready for operation to be furnished with lathe. Friction-clutch pulleys for crossed and open belt to be provided on counter.

## CLASS K.

### *Specifications for one (1) 26-inch slotter.*

This machine is to slot to a center of at least 72 inches, and is also to be used for cutting out sections of screw in breechblocks. To be fitted with compound and circular tables. Longitudinal traverse to be 40 inches and transverse traverse of tables 36 inches. Circular table to be 50 inches diameter. Ram driven by rack, pinion, and tangent gear, or by crank with quick return on up stroke. Ram guide adjustable for height, and having at least 27 inches clear space under it when in the highest position.

*Ram.*—To be made of hard close-grained iron, containing 25 per cent of cold-blast iron. To be provided with rack on the back not less than 1¾-inch pitch, 6-inch face. Ram to have adjustable reverse tappets on its face, and is to be provided with relief tool holder so arranged that the tool point can be raised or lowered while the ram is in motion, in order to slot along pitch line of screw. Length of ram to be not less than 6 feet, and to be well counterbalanced, and provided with "Whitworth" quick-return motion.

If tangent gearing is used for driving it is to be attached to pinion shaft and surrounded by casing. Worm and gear to be made of cold-blast iron, and worm to be well provided with antifriction washers to take up end thrust. Pitch of worm to be not less than 2 inches. Worm to be driven by open and cross belts on large-sized pulleys, so proportioned as to give a return speed to ram of two to one.

*Rack pinion.*—To be of sound steel casting or forging. To have not less than 19 teeth, 1¾ inch pitch, 6½-inch face.

*Ram guide.*—To be adjusted vertically to heights ranging from 10 to 27 inches above table. To be provided with screws and gears for easy adjustment, and with ample surface for wear of ram.

*Feeds.*—Longitudinal, transverse, and circular feeds to be provided, ranging from about $\frac{1}{80}$ inch to ⅛ inch. Feed preferably to be driven by cam motion from main driving gear, and to take place always at the upper end of stroke, never during the cut. Feed must be absolutely uniform and positive.

*Tables.*—Slotter to be fitted with compound tables for longitudinal transverse, and circular motion. Circular table to have 50 inches diameter, square, with corners off, and to be securely gibbed to square table by four gibs placed at the corners of the latter. Circular table to be provided with bronze tangent gear and steel worm for circular feed. Centering stud or mandrel to be carefully fitted to center of circular table, and readily removable to clear the same.

*Chuck.*—A special chuck for holding breechblocks while being slotted must be furnished with machine. The chuck to hold breechblock firmly in position and allow of the same being revolved on its axis for resetting without disturbing the central alignment.

*Bed and column.*—To be cast in one piece. It is desirable that the distance from the front of column to tool point be restricted to the smallest possible. The bed to be well extended to the front, to enable work of large diameter being placed before tool without tables overhanging bed.

*Driving shaft.*—To have diameter of not less than 5 inches and to be of open-hearth steel.

*Driving cone.*—To have four steps for 5-inch belt, ranging from about

30 to 18 inches, giving, with two countershaft speeds, 8 speeds to ram. Cone to be strongly geared to driving crank in ratio of about 10 to 1.

*Gearing.*—All gearing must be accurately cut, and unless otherwise specified shall be made of strong, close-grained iron containing 25 per cent of cold-blast iron.

All shafts and screws must be of a good quality of steel, and all bolts shall be made of steel or refined iron, and all nuts frequently used shall be casehardened.

The workmanship throughout to be first-class. All surfaces in contact with moving parts must be carefully scraped to good true bearings. All necessary countershafts, pulleys, wrenches, and other appliances to complete machine ready for operation must be furnished.

## CLASS L.

### *Specifications for one (1) 12-inch slotter.*

Machine to be driven by crank with "Whitworth" quick-return motion. Distance from column to point of tool to be not more than 30 inches.

*Compound table.*—To be fitted to point of column with longitudinal, transverse, and circular feeds in all directions by power.

*Feeds.*—To take place always at the upper end of stroke, never during the cut or while the tool is on the return. Range of feeds to be from $\frac{1}{100}$ inch for the finest to $\frac{3}{16}$ inch for the coarsest on a diameter of 50 inches. Feed must be absolutely uniform and positive.

*Ram guide.*—To be adjustable for various heights, and to leave about 16 inches clear between it and circular table when in the highest position.

*Material.*—The driving shaft to be made of open-hearth steel, not less than $3\frac{1}{2}$ inches diameter, containing not less than one-half per cent carbon. All other shafts and feed screws to be made of good machinery steel, and all bolts to be made of steel or refined iron. All nuts frequently used to be casehardened.

*Gearing.*—Driving pinion to be of forged steel, and all other gearing to be of steel, or strong close-grained cast iron containing 25 per cent of cold-blast iron.

*Countershaft.*—To be provided with pulleys for two changes of speed.

*Driving cone.*—To have four steps for 4-inch belt, ranging from about 10 to 20 inches in diameter, giving two changes in countershaft, eight speeds to ram. Slowest speed to be not more than 10 or 12 feet per minute. Cone to be geared to driving crank in ratio of 8 to 1, or preferable 9 to 1. Main driving gear to be about $\frac{3}{4}$-inch pitch, $3\frac{1}{2}$-inch face, and about 30 inches pitch diameter. Largest step in cone to be extra heavy to serve as balance wheel.

*Ram.*—To be connected to crank by steel-forged rod of heavy section not less than 22 inches long. Stroke of ram to be 13 inches. Ram to be supported in back by adjustable guide. Ram to be counter-weighted and provided with screw for hand adjustment to any vertical position. Length of ram to be at least 50 inches, more length desirable. In addition to clamps for holding rigid tools the ram is to be provided with a swinging tool holder on the lower end to take release tool.

*Compound tables.*—The lower table should be 36 inches long by 21 inches wide, and have bearing on bed 16 by 20 inches.

*Intermediate table.*—To be 20 inches square, and have transverse traverse of 21 inches. Circular table to be 30 inches in diameter, and fitted with worm wheel of hard bronze, located under circular table, and protected from chips and dust.

Cranks for moving tables by hand to be placed in convenient position for operator, and feeds arranged to be easily engaged or disengaged.

*Column.*—To be not less than 15 inches wide and, as nearly as possible, 24 inches deep, with front extended out to form bed for tables. Length of bed to be sufficient to allow circular slotting on a diameter of 30 inches.

Workmanship and material to be first-class throughout.

All necessary countershafts, pulleys, hangers, wrenches, and other appliances to complete machine ready for operation to be furnished with machine.

## CLASSES M AND $M_1$.

### *Specifications for one 32-inch, one 44-inch, and one 72-inch planer—general description.*

Machines are to be driven by tangent gearing transmitting motion to the table rack.

*Feeds.*—To be by power in all directions, and actuated by positive gearing and not by friction.

*Bed and table.*—To be in all cases of extra depth, with ample bearings in ways. Table ways are to be lubricated by conical brass rollers inserted at suitable distances in the bed. Sides of bed to be joined by heavy box girders at housing cheeks and intervals.

*Housings.*—To be double webbed with wide faces and ample depth in the back. Front of housings must in all cases be accurately scraped to make perfect bearing against the cross rail.

*Cross rail.*—To be of extra depth and have arched back cored out. To be scraped on face to perfectly fit the head or heads, and back resting against housings to be scraped to a perfect bearing.

*Driving pulleys.*—To be actuated by open and cross belts, shifted by easy cam movement. Pulleys to be placed directly on worm shaft, said shaft to stand parallel with planer.

*Driving gear.*—The worm and worm wheel driving table, together with the intermediate gearing and table rack, are to be made of strong, close-grained iron containing not less than 25 per cent of cold-blast iron. The tangent gearing shall in all cases be triple pitch.

Cutting speed to be for steel 12 to 14 feet per minute.

Quick return to table to be provided. On smaller sizes return to range from 70 to 80 feet per minute, and on larger sizes from 50 to 70 feet. All parts subject to strains on account of sudden change of speed to be made extra heavy.

*Driving shafts.*—To be in all cases of open-hearth steel, containing not less than one-half per cent of carbon. Bearings for shafts to be bushed with hard bronze bushings, composed of 85 per cent copper and 15 per cent tin.

Material and workmanship to be first-class throughout. All shafts and feed screws not otherwise specified are to be made of steel, and all gearing to be of steel or strong, close-grained iron containing not less than 25 per cent of cold-blast iron.

All necessary countershafts, hangers, pulleys, wrenches, and other appliances to complete machines ready for operation are to be furnished with planers.

## CLASS M.

### *32-inch by 32-inch by 8-foot planer.*

To plane 32½ by 32½ inches in the clear and 8 feet long. One head fitted to cross rail.

*Table.*—To be 26½ inches wide and not less than 9 feet 4 inches long. Distance between ways to be not less than 16 inches, and ways to be not less than 3½ inches wide.

*Rack.*—To be bolted to table, and to be accurately cut 1¼-inch pitch and 4½-inch face.

*Bed.*—To be not less than 19 inches deep, with sides joined by heavy box girder at housing cheeks and at intervals. To be fitted with four brass conical rollers for lubricating table.

*Housings.*—To have face 5 inches wide and bearing on bed 32 inches long, and to have double web form.

*Cross rail.*—To have depth on face not less than 13 inches. To be fitted with one head arranged for cross and vertical feeds in all directions. Top of rail to be square gibbed for head. Cross rail to be elevated by hand.

*Driving pulley.*—To be not less than 24 inches diameter, driven by 2-inch belt, and driving table through tangent gear and rack pinion. Belt velocity to be not less than 32 times velocity of table. Return of table to be 70 feet per minute.

### *44-inch by 44-inch by 10-foot planer.*

To plane 44½ by 44½ inches in the clear and 10 feet long. Two heads to be fitted for cross rail; two side heads to be fitted, one on each housing.

*Table.*—To be 36 inches wide and not less than 12 feet long. Distance between ways to be not less than 24 inches, and ways to be not less than 4½ inches in width.

*Rack.*—To be accurately cut, 1½-inch pitch and 6½-inch face, and bolted to table.

*Bed.*—To be not less than 21 inches deep, with sides joined by heavy box girder at housing cheeks and at intervals. Bed to be fitted with six conical brass rollers for lubricating table.

*Housings.*—To have not less than 7½ inches face, bearing on bed to be 42 inches long, and fitted with ways for side heads.

*Cross rail.*—To have depth on face of not less than 15½ inches. To be fitted with two heads, arranged for cross and vertical feeds in all directions. Top of rail to be square gibbed for heads. Rail to be elevated by power.

*Driving pulley.*—To be not less than 26 inches diameter and drive the table through tangent gearing, pinion, and rack wheel. Belt velocity to be not less than 40 times the velocity of table. Return of table to be 60 feet per minute.

*Side heads.*—One side head to be fitted to each of the housings. Side-head saddles to have bearing on housings 12 inches long and bearing for slide 18 inches long. Saddles to be fitted with adjustable slides, upon which are mounted swiveling tool box and tool apron. Tool apron to be fitted with spring to drop apron into place. Power and hand feeds to be applied to side heads, and the same are to be counterweighted to enable easy manipulation by hand. Side heads to be so adjusted on housing as to drop down to allow the cross rail coming close to the table. Side heads must at all times allow work the full width of space between housings to pass between them.

### CLASS $M_1$.

### *72-inch by 72-inch by 12-foot planer.*

To plane 73 by 73 inches in the clear and 12 feet long. Two heads to be fitted for cross rail; two side heads to be fitted, one on each housing.

*Table.*—To be 60 inches wide and not less than 14 feet long. Distance between ways to be not less than 37 inches, and ways to be not less than 9½ inches in width.

*Rack.*—To be accurately cut, 2-inch pitch and 10-inch face, and bolted to table.

*Bed.*—To be not less than 23 inches deep, with sides joined by heavy box girder at housing cheeks and at intervals. Bed to be fitted with six conical brass rollers for lubricating table.

*Housings.*—To have not less than 18 inches face; bearing on bed to be 62 inches long and fitted with ways for side heads.

*Cross rail.*—To have depth on face of not less than 24 inches. To be fitted with two heads, arranged for cross and vertical feeds in all directions. Top of rail to be square gibbed for heads. Rail to be elevated by power.

*Driving pulley.*—To be not less than 36 inches diameter and drive the table through tangent gearing, pinion, and rack wheel. Belt velocity to be not less than 80 times the velocity of table. Return of table to be 50 feet per minute. Belt to be 4 inches wide.

*Side heads.*—One side head to be fitted to each of the housings. Side-head saddles to have bearing on housings 18 inches long and bearing for slide 21 inches long, with reach for slide of 18 inches. Saddles to be fitted with adjustable slides, upon which are mounted swiveling tool box and tool apron. Tool apron to be fitted with spring to drop apron into place. Power and hand feeds to be applied to side heads, and the same are to be counterweighted to enable easy manipulation by hand. Side heads to be so adjusted on housing as to drop down to allow the cross rail coming close to the table. Side heads must at all times allow work the full width of space between housings to pass between them.

### CLASS N.

### *Specifications for two (2) 26-inch shapers.*

This machine to plane longitudinal grooves in breechblocks up to 17½ inches diameter and 25½ inches length. It is to be arranged for work of a general nature with a very wide range of feeds.

Cutting speed for steel to be 13 feet per minute. Stroke of cutter-bar to be 26½ inches.

*Cutter bar.*—To be driven by connection to driving crank with variable stroke. Crank to be provided with "Whitworth" quick-return motion, approximately two to one.

*Front of bed.*—To extend very close to floor, and to be fitted with two tables, one containing vise; circular feed for ordinary work to be provided in the center of bed.

*Driving cone.*—To have four steps for 3½-inch belt, ranging about from 11 to 20 inches diameter, back geared, giving eight changes of speed.

Cone geared to driving crank in ratio of about 28 to 1. Main driving gear to be not less than 27 inches diameter, 1-inch pitch and 3-inch face; driving pinion of forged steel.

*Cutter bar.*—To be of heavy section, U-shaped preferred, with square ways on the lower side, and to have bearing on saddle not less than 10 inches wide by 48 inches long.

Length of cutter bar not less than 72 inches.

Cutter bar to have on its face a tool head with clamps and studs, set over by tangent gear, vertical movement of 8 inches, automatic up-and-down feed and adjustment of stroke during cutting. But connection between adjustable shoe and cutter bar to be arranged so as to tighten it from front of machine. Machine to have a balance wheel (running at high speed) connected with driving gear.

*Connecting arm.*—To be a forging of heavy rectangular section, not less than 42 inches between centers. To be adjustable on driving crank to any length of stroke, and adjustable on the ram by a screw and hand crank, placed to be operated from the front side of machine to allow cutter bar to be set to any desired position.

*Saddle.*—To have bearing on bed not less than 28 inches square, accurately fitted to bed, and provided with gibs for ways to take up wear. Saddle to be arranged to be moved on bed in either direction without going to end of bed to disconnect feed, and is to be further provided with pinion and large hand-wheel, gearing into main gear to allow adjusting the stroke without doing the same by belt. Saddle to be provided with a device to relieve it from bearing with its full weight on slides.

*Feed.*—Saddle feed to be by heavy screw, not less than 1¾ inches diameter, to range from $\frac{1}{100}$ to $\frac{1}{10}$ inch. Feed to be reversible. Circular feed to be provided for mandrel in center of bed for circular work.

*Bed.*—To be about 100 inches long and not less than 28 inches wide on top. To be provided with square ways, and front to extend very close down to floor, legs projecting about 9 inches in front on each end of bed. Front to be T-slotted to receive work. Saddle to have 70 inches movement on bed.

*Work-tables.*—To be two in number; to be movable lengthwise on the bed, and adjustable on same by screws operated by hand cranks. One table to be of box-form, 24 inches square, and T-slotted on top and sides to receive work. One table to be provided with movable platen 24 inches square, and heavy swiveling vise. Tables to be raised and lowered by screw and hand crank, so placed that stooping is avoided.

*Special center head.*—To consist of heavy slide, not less than 6 inches deep by 12 inches wide. Slide to be provided with head fitted with center revolved by indexed tangent gear, and with tail-block fitted with adjustable center. The whole to be very massive, calculated to plane lengthwise in breechblocks 18½ inches diameter by 25½ inches long, breechblocks being mounted on mandrels and placed between the centers. Automatic circular feed, transmitted through the tangent gear and operated by the movement of cutter bar, to be provided. Finest feed to be not over $\frac{5}{1000}$ of one inch.

Tailstock center to have set-over for cutting tapers. Cutter head to be mounted on the box-shaped work-table and securely clamped.

Workmanship and material to be first-class throughout. All shafts and feed screws to be of good machinery steel; all bolts to be of refined iron, and all nuts frequently used to be casehardened.

*Gearing.*—To be accurately cut, and to be made of strong close-grained iron, containing 25 per cent of cold-blast iron.

All bearing surfaces must be accurately scraped.

Countershafts, hangers, pulleys, wrenches, and all appliances to complete machine ready for operation to be furnished with machine.

## Class O.

### *Specifications for two (2) 18-inch shapers.*

*Cutter bar.*—To have 18½ inches stroke and quick return by “Whitworth motion. Bar to be not less than 48 inches long, and to have bearing on saddle not less than 8 inches wide by 30 inches long. Bar to be fitted to saddle with square gibs, and to be adjustable by screw operated by hand crank on front of machine.

Head to be operated by tangent gear; vertical feed to be automatic.

*Saddle.*—To have 60 inches traverse on bed with bearing not less than 24 by 24 inches, or like area. Saddle to have opening nut on feed screw, and to be quickly movable on bed by rack and pinion.

*Feed.*—Saddle feed to be by heavy screw, and range from $\frac{1}{100}$ to $\frac{1}{10}$ of one inch. Feed to be reversible. Vertical feed automatic.

*Driving cone.*—To have four steps for 3½-inch belt, smallest step to have not less than 10 inches diameter. Countershaft to be arranged with two sets of pulleys, giving eight speeds to cone. Cone to be geared to driving crank in a ratio of about 7 to 1.

*Bed.*—Bed to be at least 22 inches wide on top, and front extended down to the floor, and provided with T-slots to hold work.

Circular feed mandrel to be placed in center of front bed. Mandrel to be not less than 2½ inches diameter and fitted to revolving bush, provided with automatic feed by tangent gear.

*Work-tables.*—To be two in number, placed on the front of bed and movable lengthwise on the same by screws operated by hand cranks. One table to have box form not less than 18 by 18 inches, and T-slotted on top and sides. One table to have square platen, not less than 18 by 18 inches, removable, to be replaced by swiveling vise.

Vertical adjustment of tables by screw and hand cranks so placed that stooping is avoided. Adjustment to be 18 inches.

A pair of centers of heavy design, for shaping circular work, to be provided.

Workmanship and material to be first-class throughout.

*Gearing.*—To be accurately cut, and to be of steel or strong close-grained iron containing 25 per cent of cold-blast iron. All shafts and screws to be of good machinery steel, and all bolts to be of refined iron. All nuts frequently used must be casehardened.

All bearing surfaces must be accurately scraped to bearing.

Countershaft, hangers, pulleys, wrenches, and all other appliances to complete machine ready for operation to be furnished.

## Class P.

### *Specifications for one (1) universal radial drilling machine.*

The machine to consist of a heavy L-shaped soleplate, upon which is mounted the drill column, arranged to revolve about a fixed sleeve on the soleplate. Upon the column is fitted, by a long sleeve, the drill arm, carrying the drill head.

*Drill head.*—To move laterally on the arm and to revolve to any position from horizontal to vertical on the saddle. Traverse of drill spindle to be about 15 inches. Maximum height under drill spindle to be not less than 5 feet 6 inches, and greatest distance from column to center of spindle to be 72 inches.

*Driving shaft.*—To be central, with column to revolve completely around.

*Driving cone.*—To have four steps for 3-inch belt, and geared to drill spindle, by back gear in ratio of 10 to 1, giving eight changes of speed.

*Drill arm.*—To have sleeve in column at least 30 inches long, provided with clamp bolts. Arm to be of massive box form, having on its front face the ways for drill head. Shaft for driving spindle to extend lengthwise through the arm. Drill arm to be raised and lowered by screw bedded in column, and operated by reversing gear under easy control of the operator. Arm to carry frame for cones and back gear.

*Column.*—To be at least 13 inches diameter, provided with flange on bottom 32 inches diameter, and carefully fitted to sleeve, extending well up into column, and bolted to soleplate. Column to revolve with great freedom. Top of column to be surmounted by cap carrying the driving spur gears and reversing gear for elevating screw. Rotating device of column to be such that tool point is not thrown out of line when tightening up clamping bolts.

*Soleplate.*—To be of L-form, with one wing forming a flat table and the other provided with a tilting table 48 inches square. Column of tilting table to be very strong, and base arranged with rotating device, by worm and worm gear. Soleplate to be at least 7 inches deep and to have lugs for foundation bolts.

*Drill head.*—To consist of a saddle fitted to ways on the arm, and quickly adjusted to any position on arm by rack and pinion, and clamped in place. To the saddle is fitted the swiveling head carrying drill spindle. Head to swivel from vertical and horizontal position.

*Spindle.*—To be of open-hearth steel, containing at least ½ per cent carbon, 2¾ inches diameter, and having vertical traverse of about 15 inches.

*Feed.*—Two changes of power feed to be provided by positive gearing operated by clutch pin. Feed to be of transmitted through screw provided with double nut, arranged to allow all lost motion to be taken out.

*Gearing.*—All small pinions to be of forged steel, and all other gear to be of strong, close-grained cast iron, containing not less than 25 per cent of cold-blast iron. All shafts and feed screws to be of good quality machinery steel, and all bolts to be of refined iron. All nuts frequently used to be casehardened.

Workmanship and material to be first class throughout.

Countershaft, pulleys, hangers, wrenches, and all other appliances to make machine complete ready for operation are to be furnished with drill.

## CLASS R.

### *Specifications for one 24-inch and one 36-inch vertical drill.—General description.*

Drills to consist of a strong, substantial column mounted on heavy soleplate. Column to reach over at top and take upper end of drill spindle. Driving cone with back gear to be supported by bracket at the upper end of column. Cone to be driven by belt coming from lower cone, placed near the base of column.

Lower end of drill spindle to be supported by head movable vertically on the face column, and fitted to column by ways and clamping gib.

Feed to spindle is by rack sleeve surrounding spindle, and taking up the thrust or spindle by annular washers of vulcanized fiber.

Table to be square or rectangular compound table. Table to be provided with slots for clamping work, and mounted on a substantial bracket or arm, and having vertical adjustment by rack and pinion.

Arm to be provided with clamps to hold it firmly in position on column and clamp table in place, and to be adjustable vertically by screw bevel gear, shaft, and crank.

### *24-inch drill.*

*Driving cone.*—To have four steps for 2-inch belt, largest step not less than 9 inches diameter. Cone geared to spindle in ratio of about 6 to 1.

*Spindle.*—To be not less than 1¾ inches diameter, and made of open-hearth steel, containing one-half per cent of carbon. Spindle to be inclosed in feed-rack sleeve, and to have traverse of at least 8 inches. Spindle to be provided with antifriction washer to take up thrust.

*Drill head.*—To be accurately fitted to ways on the front column and movable vertically on the same through a distance of not less than 21 inches, and provided with clamp to hold head in position.

*Counterweight.*—Counterweight to be provided for balancing drill head and spindle. Chain and sheaves to be so arranged that one weight will balance both head and spindle. Weight to hang inside the column.

*Feed.*—Two changes of feed by power to be provided, and hand feed and quick return by hand to be provided for.

*Column.*—To have lower end turned to take table; support and front planed for drill head. Back of column provided with arms to take driving cones and back gear. Diameter of column to be not less than 8 inches in the part turned to receive table.

*Drill head.*—To have bearing on column 12 inches long and 6½ to 7 inches wide, counterbalanced and provided with clamp gib to hold to column.

*Table.*—Compound table to be 24 inches square.

*Table arm.*—To be bored to fit column and have bearing on column not less than 10 inches deep.

*Soleplate.*—To be not less than 3 inches in depth, about 38 inches long, and 20 inches wide, to be accurately bored to a driving fit on column.

Workmanship and material to be first-class throughout. All bearings to be accurately fitted. All shafts to be of good machinery steel unless otherwise specified.

All gearing to be of steel or strong, close-grained iron, containing 25 per cent of cold-blast iron. All bolts to be of refined iron and all nuts frequently used to be casehardened.

Driving pulleys to be placed directly on machine and all wrenches and other appliances required to complete machine ready for operation to be furnished with drill.

Distance from soleplate to lower end of spindle when in its highest position to be 4 feet 6 inches or more.

### *36-inch drill.*

*Driving cone.*—To have four steps for 2½-inch belt, largest step not less than 15 inches in diameter. Cone geared to spindle in a ratio of 10 to 1. Back geared, giving eight changes of speed.

*Spindle.*—To be not less than 2½ inches diameter and made of open-hearth steel containing one-half per cent of carbon. Spindle to be inclosed in feed-rack sleeve, and to have traverse of at least 14 inches. Spindle to be provided with antifriction washer to take up thrust.

*Drill head.*—To be accurately fitted to ways on the front of column, and movable vertically on the same through a distance of not less than 21 inches, and provided with clamp to hold head in position.

*Counterweight.*—Counterweight to be provided for balancing drill head and spindle. Chain and sheaves to be so arranged that one weight will balance both head and spindle. Weight to hang inside the column.

*Feed.*—Three changes of feed by power to be provided, and hand feed and quick return by hand to be provided for,

*Column.*—To have lower end turned to take table support and front planed for drill head. Back of column provided with arms to take driving cones and back gear. Diameter of column to be not less than 11 inches in the part turned to receive table.

*Drill head.*—To have bearing on column not less than 15 inches long and 9 to 10 inches wide, counterbalanced and provided with clamp gib to hold to column.

*Table.*—Compound table 36 inches square.

*Table arm.*—To be bored to fit column and have bearing on column at least 15 inches deep.

*Soleplate.*—To be not less than 5½ inches in depth, about 4 feet 8 inches long, and 2 feet 8 inches wide, and to be accurately bored to a driving fit on column.

Workmanship and material to be first-class throughout; all bearings to be accurately fitted. All shafts to be of good machinery steel unless otherwise specified. All gearing to be of steel or close-grained iron containing 25 per cent of cold-blast iron. All bolts to be of refined iron, and all nuts frequently used to be casehardened. Driving pulleys to be placed directly on machine and all wrenches and other appliances required to complete machine ready for operation to be furnished with drill.

Distance from soleplate to lower end of spindle when in its highest position to be not less than 5 feet.

## CLASS $R_1$.

### *Specifications for one (1) 50-inch drill to take work 50 inches diameter.*

Machine to consist of a heavy soleplate, on which is mounted the column, carrying on its back at upper end the driving cone and back gear. The upper end of column reaches over and forms bearing for the upper and lower ends of spindle.

Lower part of column to be turned to fit table arm and provided with heavy flange to bolt to soleplate. Table arm to be fitted to column and arranged to revolve about the same and fitted with square compound table and provided with vertical adjustment. Countershaft with driving pulleys to be provided for this machine.

*Driving cone.*—To have four steps for 3-inch belt. Largest cone to be about 18 inches diameter and geared to spindle in ratio of about 12 to 1, provided with back gear giving eight changes of speed.

*Spindle.*—To be not less than 3¼ inches diameter and made of open-hearth steel containing ½ per cent of carbon. To have traverse of 15 inches, and provided with quick return by lever, and well provided with antifriction washers to take up thrust.

*Feeds.*—To be driven by belt, to be three in number, and transmitted to spindle by rack sleeve. Counterbalance to be provided for spindle; also hand feed.

*Table arm.*—To have bearing on the column from 16 to 18 inches deep. To be capped and provided with clamp bolts to clamp to column. To be adjusted vertically by screw, bevel gear, shaft, and crank. To be provided with stop pin to bring center of arm exactly under center of spindle.

Arm to project from edge to column about 40 inches, and to be fitted with ways for square table at least 18 inches wide. Arm to be provided with bored hub to receive bushings for boring bars. Hub to bore 4½ inches.

*Compound table.*—To be at least 30 inches square and fitted to perfect bearing on table arm, and provided with gib to take up wear. Table to move laterally on arm by screw operated by hand wheel underneath. Table to have opening through center to allow boring bar to reach into table arm, and to be provided with detachable circular table, 48 inches diameter, operated by worm gearing.

*Column.*—To be turned to 12½ inches diameter to receive table arm. Front of column to have slot accurately planed to receive bronze nut for elevating and lowering table arm. Column to contain all the bearings for driving cone, back gear, and spindle. Lower spindle bearing to receive bronze bush not less than 10 inches long, bored to fit spindle. Flange on lower end of column to be at least 20 inches diameter, not less than 1¾ inches thick, and bolted to soleplate by at least four heavy bolts.

*Soleplate.*—To be not less than 7 inches thick, 6 feet long, and 3 feet 6 inches wide. To be provided with slots for clamping work and bored to 4½ inches exactly under center of spindle to take boring bars. Distance from soleplate to lower end of spindle to be 56 inches.

Material and workmanship to be first-class throughout. All bearings must be accurately fitted. All gearing to be of steel or strong, close-grained iron containing 25 per cent of cold-blast iron.

All shafts not otherwise specified to be of good machinery steel, and all bolts to be of refined iron. All nuts frequently used to be casehardened. Countershaft, pulleys, hangers, wrenches, and all other appliances to complete machine ready for operation to be furnished with drill.

### CLASS S.

*Specifications for one (1) 66-inch horizontal boring and drilling machine.*

This machine is to bore to a center of 66 inches diameter. Longitudinal table to be 7 feet long and fitted with compound table surmounted by circular table. Outer end of longitudinal table to be supported by a yoke, which also forms the bearing for the end of boring bar.

*Driving cone.*—To have 5 steps for 3½-inch belt, ranging from about 8 to 18 inches diameter. Cone to be strongly back-geared to spindle sleeve in ratio of 10 to 1, giving ten changes of speed. Speeds to be adapted for steel.

*Spindle sleeve.*—To be of strong close-grained cast iron and running in brass bearings composed of 90 copper and 10 tin.

*Spindle.*—To be of open-hearth steel, containing ½ per cent of carbon. Diameter to be 4 inches. Spindle to have traverse of 5 feet, obtained by two settings of same. Spindle to have quick return by hand: spindle to have a 1-inch rough hole bored from end to end, and to be provided with a detachable bearing for milling at a diameter of 32 inches or less.

*Feeds.*—To be adapted for steel. To be four in number, two for drilling and two for boring, driving by positive gearing from headstock, and transmitting motion to spindle by rack and pinion or otherwise. All handwheels and levers for operating spindle and feeds by hand to be in convenient location in front of headstock.

*Longitudinal table.*—To be 7 feet long and 24 inches wide and fitted to ways on front of headstock and provided with clamp gibs on same. Table to be supported at the outer end in yoke and fitted with elevating gear for hand and power.

*Compound table.*—Intermediate table to be fitted to longitudinal table. To be 24 inches wide and 36 inches long, and to have automatic longitudinal feed.

*Cross table.*—To be fitted to intermediate table. To be 36 inches wide and about 58 inches long.

*Circular table.*—To be mounted on cross table. To be 48 inches in diameter and provided with special power feed for circular milling. Feed to be transmitted to circular table by tangent gear. Table to be provided with clamp gibs for holding in position when used for other purposes. Feed to range from $\frac{1}{40}$ inch per revolution for the finest to $\frac{1}{8}$ inch for the coarsest, on diameter of 42 inches. Feeds to be four in number.

*Facing head.*—To be provided to go on flange of spindle sleeve.

*Headstock.*—To be of strong box form, with interior arranged for tool closet.

*Soleplate.*—To be at least 7 inches deep and 30 inches wide, and provided with lugs for foundation bolts.

*Elevating screws.*—To be of good quality machinery steel, not less than 3½ inches in diameter, and fitted into nuts not less than 7 inches long. Pitch to be from $\frac{1}{3}$ inch to $\frac{1}{2}$ inch.

*Material.*—All pinions of small diameter to be made of steel forging, and all other gearing to be of close-grained cast iron containing 25 per cent of cold-blast iron. All shafts and feed screws to be made of good machinery steel, and all bolts of steel or refined iron. All nuts frequently used to be casehardened.

Workmanship and finish to be first-class throughout.

All necessary countershafts, pulleys, hangers, wrenches and other appliances to complete machine ready for operation to be furnished with machine.

## CLASS T.

### *Specifications for one (1) vertical milling machine (heavy).*

This machine must be strongly built throughout, and admit weights of 1,200 pounds on the table without excessive wear or any injury to the machine. The mill spindle is to be vertical, and is to have 7 inches diameter at the largest part. It must admit work 26 inches high and 46 inches in diameter; thus the distance from center of spindle to face of column must not be less than 23 inches.

The diameter of table over T-slots should be as large as possible, but not less than 32 inches.

The machine is to be powerfully geared for heavy work, and all feeds must be adapted for steel.

Besides the necessary milling speeds the machine must be provided with at least two drilling speeds.

The spindle is to be carried in a bearing which can be raised or lowered in order to bring the cutter into a suitable position for operating work of varying depths.

The carriage is to have longitudinal, transverse, and circular power and hand feeds.

The automatic feed must be reversible.

Material and workmanship must be first-class in every respect.

The machine is to be furnished complete with countershaft, pulleys, wrenches, drip pan, and reservoir for oil, etc.

### CLASS U.

*Specifications for one (1) Universal milling machine No. 3, as manufactured by the Brown & Sharpe Manufacturing Company.*

This machine is to allow the use of cutters up to 8 inches in diameter. Cone to have three steps for 3½-inch belt. Machine to have six changes of feed and the same number of changes of speed. The table, 40 by 7 inches, has an automatic feed of 22 inches; it can be lowered to a distance of 17 inches from center of spindle and set at angles up to 44 degrees each way from the axis of spindle. Machine to be provided with spiral head, vise, etc.

The following tools to be furnished with the machine:

One half-inch screw arbor.
One inch screw arbor.
One inch milling arbor.
Fly cutter arbor with tool.
Collet and key for small end mills.
End mill ⅜ inch diameter.
End mill, $\frac{3}{16}$ inch diameter.
End mill, ⅞ inch diameter.
End mill, 1¼ inches diameter.
Face mill, 4 inches diameter, 1-inch face, 1-inch hole.
Milling cutter, $1\frac{11}{16}$ inches diameter, $\frac{3}{16}$-inch face, ½-inch hole.
Milling cutter, 2½ inches diameter, 3-inch face, 1-inch hole.
Milling cutter, 2¼ inches diameter, 1-inch face, for milling teeth of spiral mills, 40 degrees and 12 degrees.
One pair straddle mill cutters, 4 inches diameter, ⅝-inch face, 1-inch hole.
Metal slitting saw, 3 inches diameter, $\frac{1}{16}$-inch face, 1-inch hole.
Sixty degrees angular cutter, 1⅜ inches diameter, ½-inch hole, right hand.
Sixty degrees angular cutter, 1⅜ inches diameter, ½-inch hole, left hand.
Sixty degrees angular cutter, 2¼ inches diameter, 1-inch hole, right hand.

All necessary countershafts, pulleys, hangers, wrenches, and other appliances to complete machine ready for operation to be furnished with machine.

### CLASS $U_1$.

*Specifications for one (1) No. 2 vertical spindle milling machine, as built by the Brown & Sharpe Manufacturing Company.*

The platen of this machine is gibbed solidly to a broad and substantial base and rests upon flat and ample bearings. It is 41 inches long and 13¾ inches wide, and is fed in either direction automatically or by hand its entire length and width. It has eight changes of speed for each speed of spindle. At its lowest point the spindle is to be 1½ inches and at its highest 15 inches above the platen. Spindle to have 12 speeds. Machine to allow cutters up to 8 inches diameter to be used for surfacing.

Circular milling attachment, 18 inches in diameter, with automatic feed in either direction, is to be furnished.

Countershafts, hangers, pulleys, wrenches, and all appliances to complete machine ready for operation, to be furnished with machine.

## CLASS V.

### *Specifications for two (2) "heavy" milling machines, manufactured by Pedrick & Ayer.*

The machine must possess "vertical" and "angular" attachment; it must be adapted for cutting racks, and spur and bevel gears up to 40 inches diameter, for profiling or angular milling, combing or drilling at right angles to the main spindle of the machine, cutting up square stock by saws, milling of slots, arcs or circles, dies for sheet metal, square pieces on edge, etc. Bidders to state size of largest and smallest gears the machine will cut.

The spindle to be of steel, and the front end to run in solid self-centering boxes. Spindle to be threaded on the end to screw on large inserted tooth-mills, etc. The hole in the end of spindle to receive arbors, bushings, etc.; to be about 12 inches long, 2 inches diameter at outer and 1½ inches at inner ends, so as to be practicable for heavy work.

The overhanging arm to be of hammered steel; it should move out to support cutter arbors 26 inches from end of spindle, and should be arranged to be pushed back or moved out of the way entirely when not in use.

The knee to have a bearing of 24 by 14 inches and a vertical movement of 19½ inches. Its movement in line with the spindle to be 12 inches.

Table or platen to be 48 by 14 inches, horizontal feed 12 inches, transverse feed 32 inches. It should have three T-slots for ¾-inch bolts on top. It must be placed end for end or in line with spindle, and its feed is to operate automatically while in any position. There must be three feeds, one for table, one in line with the spindle, and one up-and-down feed, all reversible and automatic, with automatic stops.

All feeds to be arranged for steel-milling. Feed to be driven by a 2-inch belt, and motion further conveyed through cut gears and clutches. It must be reversible and operated by a lever of such construction as to remain in any position desired. This lever is to control all different feeds in all directions and to work with automatic stops. All feed gears to be of steel, cut. Dials to read in decimals. Index head to swing 16 inches. Vise to swing at any angle from 0 to 90 degrees, to have hardened-steel jaws 8 by 2 inches, and to open 5½ inches.

Countershafts to have two clutch pulleys, and to have facilities for oiling while pulleys are reversing. Hangers, drip cups, shifter rod, and all necessary appurtenances to be furnished for countershaft.

With this machine will be furnished:

**Index head with back center.**
**Vertical and angular attachment.**
**Universal vise chuck.**
**And such other attachments as are manufactured by Pedrick & Ayer for this machine.**

## CLASS W.

*Specifications for one (1) profiling machine.*

This machine must be provided with a large, strong, and well-supported table, capable of receiving and supporting a solid steel plate of 42 inches in diameter and 6 inches height. The spindle (single) must be arranged for work of these dimensions, and should be provided with Parkhurst's patent device for cutting formers without reversing the fixtures.

Countershaft, hangers, pulleys, wrenches, and all appliances to complete the machine ready for operation, must be furnished with it.

## CLASS X.

*Specifications for one (1) drill grinding machine with pointing attachment, as built by Wm. Sellers & Co.*

This machine is to be adjustable for all angles of drill points from 90 to 130 degrees, and must be furnished complete, and with all attachments manufactured for it by Wm. Sellers & Co.

Countershaft, hangers, pulleys, wrenches, and all appliances to complete machine ready for use, must be furnished.

## CLASS Y.

*Specifications for one (1) emery wheel tool grinder No. 5, as manufactured by the Springfield Glue and Emery Wheel Company.*

Emery wheel to have 36 inches diameter and 4 inches width. Hood of wheel to have a suitable opening, with cover on back for grinding long tools.

This machine is to be furnished with water tanks, centrifugal pump piped, slide rest, countershaft, hangers, pulleys, wrenches, and all appliances to complete machine ready for use, including one diamond-point tool for dressing emery wheel.

## CLASS Z.

*Specifications for one (1) screw machine.*

This machine is to cut screws ranging from ⅝ inch to 1½ inches, inclusive, in diameter, and for bolt lengths of 9 inches under the head.

Cone spindle to be provided with double-ended clutch engaging cone and back gear, or other suitable mechanism, by which the spindle can be instantly changed from slow to fast, or stopped or started without shifting belt on countershaft.

Front end of spindle to be provided with chuck of sufficient power to hold work while being operated on.

Carriage to have large bearing on bed, to be provided with power feed for turning. Tool rest to be fitted with two tool posts, one on the front and one on the back. Tool-rest to be fitted to a slide operated by cam to engage or disengage the lead screw with nut, when cutting threads with tool in tool post.

Die plate with opening and closing dies to be mounted on the carriage, and provided with dies for all the diameters within the range of machine.

*Turret.*—To be mounted on a substantial base, and provided with six holes for taking the several tool and die holders.

*Turret base.*—To have large bearing on bed. To be provided with two changes of power feed, and quick movement by hand on the bed. To be further provided with mechanism for automatically revolving turret, and adjustable to any position on the bed.

*Bed.*—To rest on trough designed to catch the oil dripping from dies and tool-holders. Said trough to be provided with a strainer, allowing the oil to flow back into the reservoir.

*Oil pump.*—To be provided and operated by power. Said pump to convey the oil to lubricating pipes or spouts provided with stopcocks. By-pass valve to be provided, by which means the oil will flow back from pump to reservoir and avoid stopping the pump when the outlet cocks are closed.

*Equipments.*—Machine to be furnished with the following equipments for turning and chasing screws, viz:

Center for turret,
End gauge,
Turner with 6 bushes,
Sizer with 6 bushes,
Die-holder with 6 dies,
Open dies, 6 sizes,
Six (6) open-die hobs,
Six (6) holes for lead-screw nut,
Six (6) nut taps,
Six (6) lead screws with nuts,
Six (6) solid in-and-out calipers;

all for cutting the following sizes of screws, viz: $\frac{5}{8}$-inch, $\frac{3}{4}$-inch, $\frac{7}{8}$-inch, 1-inch, $1\frac{1}{4}$-inch, and $1\frac{1}{2}$-inch.

Workmanship and material to be first class throughout.

All necessary countershafts, pulleys, hangers, wrenches, and other appliances to complete machine ready for operation to be furnished with machine.

# APPENDIX 34.

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## *REPORT ON FIRINGS WITH 13½-POUND 3.2-INCH SHELL WITH BANDS AT 1¼ INCHES, AND ⅝ INCH FROM BASE.*

(Ten plates.)

In accordance with instructions of May 29, 1890, firing was conducted at Sandy Hook Proving Ground at targets placed 1 mile and 3,000 yards with 3.2-inch shell, having bands placed at 1¼ inches and five-eighths inch from the base. Heretofore the bands of the 3.2-inch shell have always been placed 1¼ inches from the base, and the original instructions directed a comparison to be made with targets previously obtained. These instructions were subsequently modified, until finally they directed a comparison between shells 3 calibers long with heads having 2 calibers radius and weighing 13½ pounds.

The accompanying firing and target records give the results obtained in the first series of firings, which sum up as follows:

| Distances of band from base, in inches. | Accuracy. | | | | | | Angle of fire. | Velocity. | Pressure. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | No. of shots fired. | No. of hits. | No. of misses. | Deviation from center of impact. | | | | | | |
| | | | | Mean horizontal. | Mean vertical. | Mean. | | | | |
| | | | | | | | ° ′ | | | |
| At one (1) mile: | | | | | | | | | | |
| 0.625 inch | 10 | 9 | 1 | 2.456 | 1.531 | 2.894 | 2 25 | 1,638 | 32,155 | Mean of three rounds. |
| 1.250 inches | 10 | 7 | 3 | 1.245 | 2.245 | 2.567 | 2 25 | 1,663 | 32,660 | |
| At 3,000 yards: | | | | | | | | | | |
| 0.625 inch | 10 | 8 | 2 | 1.687 | 4.468 | 4.775 | 5 40 | ........ | ........ | |
| 1.250 inches | 8 | 7 | 1 | 4.428 | 4.551 | 6.349 | 5 18 | ........ | ........ | |

From the above it appeared that the projectiles had nearly the same accuracy at 1 mile, while the advantage seemed to be with the shell banded at 0.625 inch from the base at 3,000 yards.

Owing to the fact that the platform from which the gun was fired in the foregoing tests was not considered sufficiently stable, a further series of firings was provided for with shell banded as before, viz, at 0.625 inch and 1.25 inches from the base.

On December 23 ten rounds were fired at 1 mile range with each kind of band and the best results were obtained with the band five-eighths inch from the base.

On December 29 ten rounds were fired at 1 mile with each kind of band and the results were slightly, but not materially, better with the band 1¼ inches from the base.

Several efforts were made in January, as shown by the records, to obtain satisfactory targets at 3,000 yards, but owing to bad conditions of light and wind they were unsuccessful until January 15, when ten rounds were fired with the band five-eighths inch from the base. Four of the shells missed the target but the six which struck it were grouped well together vertically.

Six rounds were then fired with the bands $1\frac{1}{4}$ inches from the base and the results obtained were greatly inferior to those with the other bands.

This firing was executed from a firm platform and confirms the previous results obtained and reported upon November 13, 1890.

It is therefore recommended that hereafter the band of the 3.2-inch shell be placed at a distance of five-eighths inch from the base.

Very respectfully, your obedient servant,

CHARLES SHALER,
*Captain, Ord. Dept., U. S. Army, Commanding.*

{ 3725–'90 }
{ 461–'91 }

*Record of firing with 3.2-inch B. L. rifle (steel), No. 18, West*

[Object of firing, to test relative

| | No. of fire. | Powder. | | Projectile. | | Elevation. | Wind allowance, points left. | Recoil. | Wind, strength and direction. |
|---|---|---|---|---|---|---|---|---|---|
| | | Kind. | Weight. | Kind. | Weight. | | | | |
| | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ′ | | *Feet.* | |
| P. M. | 1289 | Du Pont's I. K. H. Lot 1. Density, 1.725. Granulation, 2,050. | 3 12 | Service shell. Lot 229. | 12 14<br>6 sand.<br>4 lead.<br>13 8 | 2 00 | 1 | 10 | From front, 12 miles an hour. |
| | 1290 | | 3 12 | | 12 15<br>6 sand.<br>3 lead.<br>13 8 | 2 20 | 1 | 12 | |
| | 1291 | | 3 12 | | 12 14<br>6 sand.<br>4 lead.<br>13 8 | 2 25 | $\frac{9}{16}$ | 10 | |
| | 1292 | | 3 12 | Shell. Lot 280. Single flat band, ½ inch wide and 1¼ inches from base. | 12 15<br>9 plug.<br>13 8 | 2 25 | $\frac{9}{16}$ | 9 | |
| | 1293 | | 3 12 | | 13 0<br>8 plug.<br>13 8 | 2 25 | $\frac{9}{16}$ | 9 | |
| | 1294 | | 3 12 | | 13 1<br>7 plug.<br>13 8 | 2 25 | $\frac{9}{16}$ | 10 | |
| | 1295 | | 3 12 | | 12 15½<br>8½ plug.<br>13 8 | 2 25 | $\frac{9}{16}$ | 11 | |
| | 1296 | | 3 12 | | 13 0<br>8 plug.<br>13 8 | 2 25 | $\frac{9}{16}$ | 11 | |
| | 1297 | | 3 12 | | 12 13<br>11 plug.<br>13 8 | 2 25 | $\frac{9}{16}$ | 12 | |
| | 1298 | | 3 12 | | 13 0<br>8 plug.<br>13 8 | 2 25 | $\frac{9}{16}$ | 11 | |
| | 1299 | | 3 12 | | 12 13<br>11 plug.<br>13 8 | 2 25 | $\frac{9}{16}$ | 11 | |
| | 1300 | | 3 12 | | 12 13<br>11 plug.<br>13 8 | 2 25 | $\frac{9}{16}$ | 13 | |
| | 1301 | | 3 12 | | 12 14½<br>9½ plug.<br>13 8 | 2 25 | $\frac{9}{16}$ | 12 | |

*Point Foundry, at Sandy Hook, N. J., October 22, 1890.*

banding of projectiles.]

| Distance from center of target. | | | | Distance from center of impact. | | | | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|---|---|---|---|---|---|
| Vertical. | | Horizontal. | | Vertical. | | Horizontal. | | | |
| Above. | Below. | Right. | Left. | Above. | Below. | Right. | Left. | | |
| *Ft.* | *Ft.* | *Ft.* | *Ft.* | *Ft.* | *Ft.* | *Ft.* | *Ft.* | | |
| | | | | | | | | Gun mounted on Buffington steel field carriage (light), No. 17, with old spiral-spring brakes. Cannon friction primers (experimental), with modified priming, March, 1890. Fired from platform on fort wall. Fired at 1-mile target. Base plugs of extra length made for these shells, and used in weighting them up. Peep rear sight and cross hair trunnion sight used. | Sighting shot. Struck 100 yards in front of target and ricochetted over. |
| | 7 | | 9 | | | | | | Sighting shot. |
| | 2 | | 6 | | | | | | Sighting shot. |
| 6½ | | | 9½ | | 1.714 | | 1.286 | | |
| 9½ | | | 5½ | 1.286 | | 2.714 | | | |
| 7 | | | 6½ | | 1.214 | 1.714 | | | |
| 7 | | | 14 | | 1.214 | | 5.786 | | |
| | | | | | | | | | Miss. |
| 8 | | | 8 | | .214 | .214 | | | |
| 8½ | | | 9 | .286 | | | .786 | | |
| 11 | | | 5 | 2.786 | | 3.214 | | | |
| | | | | | | | | | Miss. |
| | | | | | | | | | Miss. |

| Center of impact: | *Feet.* |
|---|---|
| Above | 8.214 |
| Left | 8.214 |
| Mean vertical deviation from center of impact | 1.245 |
| Mean horizontal deviation from center of impact | 2.245 |
| Mean deviation from center of impact | 2.567 |

*Record of firing with 3.2-inch B. L. rifle (steel), No. 18, West*

[Object of firing, to test relative

|  | No. of fire. | Powder. |  | Projectile. |  | Elevation. | Wind allowance, points left. | Recoil. | Wind, strength and direction. |
|---|---|---|---|---|---|---|---|---|---|
|  |  | Kind. | Weight. | Kind. | Weight. |  |  |  |  |
|  |  |  | Lbs. Oz. |  | Lbs. Oz. | ° ′ |  | Feet. |  |
| P. M. | 1302 | Du Pont's I. K. H. Lot 1. Density, 1.725. Granulation, 2,050. | 3 12 | Shell. Lot 272. Single flat band, ½ inch wide and ⅜ inch from base. | 13 0<br>8 plug.<br>13 8 | 2 25 | 3/16 | 11 | From front, 12 miles an hour. |
|  | 1303 |  | 3 12 |  | 13 0<br>8 plug.<br>13 8 | 2 25 | 3/16 | 11 |  |
|  | 1304 |  | 3 12 |  | 13 1½<br>6½ plug.<br>13 8 | 2 25 | 3/16 | 12 |  |
|  | 1305 |  | 3 12 |  | 13 2<br>6 plug.<br>13 8 | 2 25 | 3/16 | 12 |  |
|  | 1306 |  | 3 12 |  | 13 0<br>8 plug.<br>13 8 | 2 25 | 3/16 | 12 |  |
|  | 1307 |  | 3 12 |  | 13 0<br>8 plug.<br>13 8 | 2 25 | 3/16 | 11 |  |
|  | 1308 |  | 3 12 |  | 13 2<br>6 plug.<br>13 8 | 2 25 | 3/16 | 12 |  |
|  | 1309 |  | 3 12 |  | 13 0<br>8 plug.<br>13 8 | 2 25 | 3/16 | 12 |  |
|  | 1310 |  | 3 12 |  | 13 2<br>6 plug.<br>13 8 | 2 25 | 3/16 | 12 |  |
|  | 1311 |  | 3 12 |  | 13 3<br>5 plug.<br>13 8 | 2 25 | 3/16 | 12 |  |

*Point Foundry, at Sandy Hook, N. J., October 22, 1890*—Continued.

**banding of projectiles.]**

| Distance from center of target. | | | | Distance from center of impact. | | | | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|---|---|---|---|---|---|
| Vertical. | | Horizontal. | | Vertical. | | Horizontal. | | | |
| Above. | Below. | Right. | Left. | Above. | Below. | Right. | Left. | | |
| *Ft.* | *Ft.* | *Ft.* | *Ft.* | *Ft.* | *Ft.* | *Ft.* | *Ft.* | | |
| 9 | ...... | ...... | 8½ | 4.889 | ...... | .777 | ...... | Gun mounted on Buffington steel field carriage (light), No. 17, with old spiral-spring brakes. Cannon friction primers (experimental), with modified priming, March, 1890. Fired from platform on fort wall. Fired at 1-mile target. Base plugs of extra length made for these shells, and used in weighting them up. Peep rear sight and cross hair trunnion sight used. | |
| 6½ | ...... | ...... | 11 | 1.889 | ...... | ...... | 1.723 | | |
| 3 | ...... | ...... | 10½ | ...... | 1.611 | ...... | 1.223 | | |
| 4 | ...... | ...... | 10 | ...... | .611 | ...... | .723 | | |
| 1 | ...... | ...... | 7 | ...... | 3.611 | 2.277 | ...... | | |
| 2 | ...... | ...... | 8 | ...... | 2.611 | 1.277 | ...... | | |
| 2 | ...... | ...... | 7 | ...... | 2.611 | 2.277 | ...... | | |
| 5½ | ...... | ...... | 9 | .889 | ...... | .277 | ...... | | |
| 8½ | ...... | ...... | 12½ | 3.889 | ...... | ...... | 3.223 | | |
| ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | | This shot was seen to strike target, but owing to number of shot holes in target its location could not be ascertained. |
| | | | | | | | | | Center of impact: *Feet.*<br>Above ........ 4.611<br>Left ........ 9.277<br>Mean vertical deviation from center of impact ........ 2.456<br>Mean horizontal deviation from center of impact ........ 1.531<br>Mean deviation from center of impact ........ 2.894<br>Piece sighted by Lieut. O. M. Lissak, O. D. Target observed by Lieut. W W. Gibson, O. D.<br>Firing conducted by the proof officer. |

*Record of firing with 3.2-inch B. L. rifle (steel), No. 18, West*

[Object of firing, to test relative

| | No. of fire. | Powder. | | Projectile. | | Elevation. | Wind allowance, points left. | Recoil. |
|---|---|---|---|---|---|---|---|---|
| | | Kind. | Weight. | Kind. | Weight. | | | |
| | | | *Lbs.* *Oz.* | | *Lbs.* *Oz.* | ° ′ | | *Feet.* |
| A. M. | 1332 | Du Pont's I. K. H. Lot 1. Density, 1.725. Granulation, 2,050. | 3 12 | Service shell. Lot 229. | 12 15<br>5 sand.<br>4 lead.<br>13 8 | 5 15 | ¼ | 12 |
| | 1333 | | 3 12 | | 12 14<br>6 sand.<br>4 lead.<br>13 8 | 5 35 | ¼ | 13 |
| | 1334 | | 3 12 | | 12 14<br>6 sand.<br>4 lead.<br>13 8 | 5 22 | ¼ | 12 |
| | 1335 | | 3 12 | Shell. Lot 280. Single flat band, ¼ inch wide and 1¼ inches from base. | 12 15<br>9 plug.<br>13 8 | 5 22 | ¼ | 12 |
| | 1336 | | 3 12 | | 12 14<br>10 plug.<br>13 8 | 5 19 | ¼ | 12 |
| | 1337 | | 3 12 | | 12 15<br>9 plug.<br>13 8 | 5 14 | ¼ | 10 |
| | 1338 | | 3 12 | Service shell. Lot 229. | 12 14<br>6 sand.<br>4 lead.<br>13 8 | 5 10 | ¼ | 10 |

*Point Foundry, at Sandy Hook, N. J., October 29, 1890.*

**banding of projectiles.]**

| | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|
| Gun mounted on Buffington steel field carriage (light), No. 17, with old spiral-spring brakes. De Bange gas-check. Base plugs of extra length made for these shells and used in weighting them up. Cannon friction primers (experimental), with modified priming, March, 1890. Peep rear sight and cross hair trunnion sight used. | |
| Fired at 3,000-yards target.................... | Sighting shot. Miss. Right brake jumped off wheel in recoiling. |
| | Sighting shot. Miss. |
| | Sighting shot. Struck target 6 feet below and 1 foot to left of bull's-eye. |
| | First primer failed; defective. Miss. |
| | Miss. |
| | Miss. |
| | Sighting shot. Struck ground 75 feet in front of target; ricochetted through target 3 feet above and 3 feet to left of bull's-eye. |
| Gun sighted by Lieut. O. M. Lissak, O. D.<br>Target observed by Lieut. W. W. Gibson, O. D.<br>Firing conducted by the proof officer. | |

*Record of firing with 3.2-inch B. L. rifle (steel), No. 18, West*

[Object of firing, to determine

| | No. of fire. | Powder. | | Projectile. | | Elevation. | Instrumental velocity, 125 feet from muzzle. | Pressure, per square inch of bore. | Recoil. |
|---|---|---|---|---|---|---|---|---|---|
| | | Kind. | Weight. | Kind. | Weight. | | | | |
| | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ′ ″ | *Feet.* | *Pounds.* | *Feet.* |
| A. M.... | 1339 | Du Pont's I. K. H. Lot 1. Density, 1.725. Granulation, 2,050. | 3 12 | Service shell. Lot 229. | 12 15<br>1 sand.<br>13 0 | 0 00 | 1,684<br>1,684<br>1,683 | .............. | 11 |
| | 1340 | | 3 12 | Shell. Lot 272. Single flat band, ½ inch wide and ½ inch from base. | 12 14<br>10 plug.<br>13 8 | 0 00 | 1,643<br>1,643<br>1,643 | No. 1, 32,046 | 11 |
| | 1341 | | 3 12 | | 13 2<br>6 plug.<br>13 8 | 0 00 | 1,634<br>1,635<br>1,635 | No. 1, 32,270 | 12 |
| | 1342 | | 3 12 | | 13 0<br>8 plug.<br>13 8 | 0 00 | 1,634<br>1,634<br>1,634 | No. 1, 32,150 | 13 |
| | 1343 | | 3 12 | Shell. Lot 280. Single flat band, ½ inch wide and 1¼ inch from base. | 12 14<br>10 plug.<br>13 8 | 0 00 | 1,662<br>1,662<br>1,662 | No. 1, 33.260 | 13 |
| | 1344 | | 3 12 | | 12 14<br>10 plug.<br>13 8 | 0 00 | 1,666<br>1,667<br>1,668 | No. 1, 33,240 | 13 |
| | 1345 | | 3 12 | | 12 13<br>11 plug.<br>13 8 | 0 00 | 1,658<br>1,659<br>1,660<br>50+[illegible] | No. 1, 32,500 | 13 |

*Point Foundry, at Sandy Hook, N. J., November 1, 1890.*

**velocities and pressures.]**

| Wind, strength and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|
| | Gun mounted on Buffington steel field carriage (light), No. 17, with old spiral-spring brakes. De Bange gas-check. Since last firing, old vent piece removed; worn out; new one inserted. Cannon friction primers (experimental), with modified priming, March, 1890. | |
| From right, 10 miles an hour. | .................................................................. | Warming charge. |
| | Fired into field butt, section 2 .................................. | Head of service rammer found broken off after this round. |
| | Copper cylinders of 32,000 pounds initial compression and tables of 1890. | |
| | Breechblock pushed home with perfect ease after insertion of cartridge. | |
| | Pressures and velocities taken by Lieut. W. W. Gibson, O. D. Firing conducted by Lieut. W. W. Gibson, O. D., assistant proof officer. | |

*Record of firing with 3.2-inch B. L. rifle (steel), No. 18, West*

[Object of firing, to test relative

|  | No. of fire. | Powder. |  | Projectile. |  | Elevation. | Wind allowance, points left. | Recoil. | Wind, strength and direction. |
|---|---|---|---|---|---|---|---|---|---|
|  |  | Kind. | Weight. | Kind. | Weight. |  |  |  |  |
|  |  |  | *Lbs. Oz.* |  | *Lbs. Oz.* | ° ′ |  | *Feet.* |  |
| P. M. | 1348 | Du Pont's I. K. H. Lot 1. Density, 1.725. Granulation, 2.050. | 3 12 | Service shell. Lot 229. | 12 13<br>6 sand.<br>5 lead.<br>13 8 | 2 15 | ½ | 9 | From right and rear, 14 miles an hour. |
|  | 1349 |  | 3 12 |  | 12 15<br>9 sand.<br>13 8 | 2 20 | ½ | 11 |  |
|  | 1350 |  | 3 12 |  | 12 13<br>6 sand.<br>5 lead.<br>13 8 | 2 18 | ½ | 11 |  |
|  | 1351 |  | 3 12 |  | 12 14<br>6 sand.<br>4 lead.<br>13 8 | 2 12 | ½ | 12 |  |
|  | 1352 |  | 3 12 |  | 12 14<br>6 sand.<br>4 lead.<br>13 8 | 2 5 | ½ | 12 |  |
|  | 1353 |  | 3 12 |  | 12 11<br>6 sand.<br>7 lead.<br>13 8 | 2 5 | ............ | 11 |  |
|  | 1354 |  | 3 12 |  | 12 14<br>6 sand.<br>2 lead.<br>13 8 | 2 8 | ¼ | 12 |  |
|  | 1355 |  | 3 12 |  | 12 14<br>7 sand.<br>3 lead.<br>13 8 | 2 11 | ½ | 12 |  |
|  | 1356 |  | 3 12 |  | 12 15<br>9 sand.<br>13 8 | 2 12 | ½ | 12 |  |

*Point Foundry, at Sandy Hook, N. J., November 3, 1890.*

**banding of projectiles.]**

| | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|
| Gun mounted on Buffington steel field carriage (light), No. 17, with old spiral-spring brakes. De Bange gas-check. Cannon friction primers (experimental), with modified priming, March, 1890. Telescopic sight used. | |
| | Sighting shot. Miss. |
| | Sighting shot. Miss. |
| | Sighting shot. Miss. |
| | Right brake jumped off wheel in recoiling. Sighting shot. Miss. |
| | Sighting shot. Miss. |
| Fired down the beach; sighted at 3,000-yards' target. | |
| | Sighting shot. Miss. |
| | Sighting shot. Miss. |
| | Sighting shot. Miss. |
| | Sighting shot. Miss. |

*Record of firing with 3.2-inch B. L. rifle (steel), No. 18, West Point*

[Object of firing, to test relative

| | No. of fire. | Powder. | | Projectile. | | Elevation. | Wind allowance, points left. | Recoil. | Wind, strength and direction. |
|---|---|---|---|---|---|---|---|---|---|
| | | Kind. | Weight. | Kind. | Weight. | | | | |
| | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ′ | | *Feet.* | |
| P. M. | 1357 | Du Pont's I. K. H. Lot 1. Density, 1.725. Granulation, 2,050. | 3 12 | Service shell. Lot 229. | 12 15<br>9 sand.<br>13 8 | 5 25 | ½ | 9 | From right and rear, 14 miles an hour. |
| | 1358 | | 3 12 | Shell. Lot 230. Single flat band, ½ inch wide and 1½ inch from base. | 12 14½<br>9½ plug.<br>13 8 | 5 22 | ¼ | 9 | |
| | 1359 | | 3 12 | | 12 15<br>9 plug.<br>13 8 | 5 18 | ½ | 9 | |
| | 1360 | | 3 12 | | 12 13<br>11 plug.<br>13 8 | 5 18 | ½ | 9 | |
| | 1361 | | 3 12 | | 12 14<br>10 plug.<br>13 8 | 5 18 | ½ | 9 | |
| | 1362 | | 3 12 | | 12 14<br>10 plug.<br>13 8 | 5 18 | ½ | 0 | |
| | 1363 | | 3 12 | | 13 0<br>8 plug.<br>13 8 | 5 18 | ½ | 9 | |
| | 1364 | | 3 12 | | 13 1<br>7 plug.<br>13 8 | 5 18 | ½ | 9 | |
| | 1365 | | 3 12 | | 13 1½<br>6½ plug.<br>13 8 | 5 18 | ¼ | 9 | |
| | 1366 | | 3 12 | | 13 0<br>8 plug.<br>13 8 | 5 18 | ½ | 9 | |

*Foundry, at Sandy Hook, N. J., November 3, 1890*—Continued.

banding of projectiles.]

| Distance from center of target. | | | | Distance from center of impact. | | | | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|---|---|---|---|---|---|
| Vertical. | | Horizontal. | | Vertical. | | Horizontal. | | | |
| Above. | Below. | Right. | Left. | Above. | Below. | Right. | Left. | | |
| Ft. | Ft. | Ft. | Ft. | Ft. | Ft. | Ft. | Ft. | | |
| .... | 4 | ...... | 4 | ..... | ...... | ...... | ...... | Gun mounted on Buffington steel field carriage (light), No. 17, with old spiral-spring brakes. De Bange gas-check. Fired from platform on fort wall. Fired at 3,000-yards target. Cannon friction primers (experimental), modified priming, March, 1890. Telescopic sight used. Base plugs of extra length made for these shells and used in weighting them up. | Sighting shot. |
| .... | ..... | ...... | ...... | ..... | ...... | ...... | ...... | | Sighting shot. **Miss.** |
| .... | ½ | ...... | 12½ | ..... | 6.50 | ...... | 4.858 | | |
| .... | 2½ | ...... | 17 | ..... | 8.50 | ...... | 9.358 | | |
| 11 | ..... | 1 | ...... | 5 | ...... | 8.642 | ...... | | |
| 7 | ..... | ...... | 9 | 1 | ...... | ...... | 1.358 | | |
| 8½ | ..... | ...... | 7 | 2.50 | ...... | .642 | ...... | | |
| 13 | ..... | ...... | 8 | 7 | ...... | ...... | .358 | | |
| 5½ | ..... | ...... | 1 | ..... | .50 | 6.642 | ...... | | |
| .... | ..... | ...... | ...... | ..... | ...... | ...... | ...... | | **Miss.** |

**Center of impact:** *Feet.*
Above .......................... 6
Left ........................... 7.642
**Mean vertical deviation from center of impact** .................... 4.428
**Mean horizontal deviation from center of impact** ............... 4.551
**Mean deviation from center of impact** .......................... 6.349
**Gun sighted by Lieut. O. M. Lissak, O. D. Target observed by Lieut. W. W. Gibson, O. D.**
**Firing conducted by Capt. D. A. Lyle, O. D., assistant proof officer.**

*Record of firing with 3.2-inch B. L. rifle (steel), No. 18, Wes*

[Object of firing, comparison of 3.2-inch shell with bands 0.625

|  | No. of fire. | Powder. |  | Projectile. |  | Elevation. | Wind allowance, points left. | Recoil. | Wind strength and direction. |
|---|---|---|---|---|---|---|---|---|---|
|  |  | Kind. | Weight. | Kind. | Weight. |  |  |  |  |
|  |  |  | *Lbs. Oz.* |  | *Lbs. Oz.* | ° ′ |  | *Feet.* |  |
| P. M. | 1367 | Du Pont's I. K. H. Lot 1. Density, 1.725. Granulation. 2,050. | 3 12 | Service shell. Lot 229. | 12 12<br>9 sand.<br>3 lead.<br>13 8 | 5 25 | ½ | 9 | From right and rear, 13 miles an hour. |
|  | 1368 |  | 3 12 |  | 12 13<br>8 sand.<br>3 lead.<br>13 8 | 5 30 | 1 | 9 |  |
|  | 1369 |  | 3 12 |  | 12 12<br>9 sand.<br>3 lead.<br>13 8 | 5 25 | 1 | 9 |  |
|  | 1370 |  | 3 12 |  | 12 14<br>8 sand.<br>2 lead.<br>13 8 | 5 40 | 1 | 8 |  |
|  | 1371 |  | 3 12 | Shell. Lot 272. Single flat band, ½ inch wide and 0.625 inch from base. | 13 0<br>8 plug.<br>13 8 | 5 40 | 1 | 9 |  |
|  | 1372 |  | 3 12 |  | 13 0<br>8 plug.<br>13 8 | 5 40 | 1 | 9 |  |
|  | 1373 |  | 3 12 |  | 13 1½<br>6½ plug.<br>13 8 | 5 40 | 1 | 9 |  |
|  | 1374 |  | 3 12 |  | 13 3<br>5 plug.<br>13 8 | 5 40 | 1 | 8 |  |
|  | 1375 |  | 3 12 |  | 13 1½<br>6½ plug.<br>13 8 | 5 40 | 1 | 9 |  |
|  | 1376 |  | 3 12 |  | 13 2<br>6 plug.<br>13 8 | 5 40 | 1 | 9 |  |
|  | 1377 |  | 3 12 |  | 13 1<br>7 plug.<br>13 8 | 5 40 | 1 | 9 |  |
|  | 1378 |  | 3 12 |  | 13 0<br>8 plug.<br>13 8 | 5 40 | 1 | 9 |  |
|  | 1379 |  | 3 12 |  | 13 0<br>8 plug.<br>13 8 | 5 40 | 1 | 9 |  |
|  | 1380 |  | 3 12 |  | 13 0<br>8 plug.<br>13 8 | 5 40 | 1 | 9 |  |

***Point Foundry, at Sandy Hook, N. J., November 5, 1890.***

**inch from base and shell with bands 1.25 inches from base.]**

| Distance from center of target. | | | | Distance from center of impact. | | | | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|---|---|---|---|---|---|
| Vertical | | Horizontal. | | Vertical. | | Horizontal. | | | |
| Above. | Below. | Right. | Left. | Above. | Below. | Right. | Left. | | |
| *Ft.* | *Ft.* | *Ft.* | *Ft.* | *Ft.* | *Ft.* | *Ft.* | *Ft.* | | |
| ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | Gun mounted on Buffington steel field carriage (light), No. 17, with old spiral-spring brakes. De Bange gas-check. Fired from platform on fort wall. Fired at 3,000-yards target. Telescopic sight used. Base plugs of extra length made for these shells and used in weighting them up. Cannon friction primers (experimental), with modified priming, March, 1890. | Sighting shot. Struck ground 100 yards in front of target. |
| ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | | Sighting shot. Struck ground 75 yards in front of target. |
| ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | | Sighting shot. Struck ground 25 yards in front of target. |
| ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | | Sighting shot. |
| 9 | ...... | ...... | 6 | .25 | ...... | 3.875 | ...... | | |
| 7 | ...... | ...... | 7 | ...... | 1.75 | 2.875 | ...... | | |
| ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | | Miss. |
| 8 | ...... | ...... | 2½ | ...... | .75 | 7.375 | ...... | | |
| 8 | ...... | ...... | 16 | ...... | .75 | ...... | 6.125 | | |
| 7 | ...... | ...... | 7 | ...... | 1.75 | 2.875 | ...... | | |
| ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | | Miss. |
| 7 | ...... | ...... | 9 | ...... | 1.75 | .875 | ...... | | Center of impact: *Feet.*<br>Above ........ 8.75<br>Left ........ 9.875<br>Mean vertical deviation from center of impact ........ 1.687<br>Mean horizontal deviation from center of impact ........ 4.468<br>Mean deviation from center of impact ........ 4.775<br>Gun sighted by Lieut. O. M. Lissak. O. D. Target observed by Lieut. W. W. Gibson, O. D.<br>Firing conducted by Lieut. W. W. Gibson, O. D., assistant proof officer. |
| 12 | ...... | ...... | 16½ | 3.25 | ...... | ...... | 6.625 | | |
| 13 | ...... | ...... | 15 | 3.25 | ...... | ...... | 5.125 | | |

*Record of firing with 3.2-inch B. L. rifle (steel), No. 26,*

[Object of firing, comparative test of 3.2-inch shell

| | No. of series. | No. of fire. | Powder. | | Projectile. | | Elevation. | Wind allowance, points left. | Recoil. | Wind, strength and direction. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | | | |
| | | | | Lbs. Oz. | | Lbs. Oz. | ° ′ | | Feet. | |
| P. M. | ...... | 6 | Du Pont's I. K. H. Lot 16. Density, 1.725. Granulation, 2,524. | 3 12 | Shell rebanded. | 12 15<br>7 sand.<br>13 6 | 2 10 | ½ | 10 | From rear and right, 15 miles an hour. |
| | 49 | 7 | | 3 12 | | 12 15<br>7 sand.<br>13 6 | 2 13 | 0 | 10 | |
| | 50 | 8 | | 3 12 | Shell (lot 297), with band ¼ inch wide and 1.25 inches from base. | 13 0<br>6 sand.<br>13 6 | 2 13 | 0 | 10 | |
| | 51 | 9 | | 3 12 | | 13 1<br>5 sand.<br>13 6 | 2 13 | 0 | 10 | |
| | 52 | 10 | | 3 12 | | 13 0<br>6<br>13 6 | 2 13 | 0 | 11 | |
| | 53 | 11 | | 3 12 | | 13 0<br>6 sand.<br>13 6 | 2 13 | 0 | 11 | |
| | 54 | 12 | | 3 12 | | 13 0<br>6 sand.<br>13 6 | 2 13 | 0 | 10 | |
| | 55 | 13 | | 3 12 | | 13 0<br>6 sand.<br>13 6 | 2 13 | 0 | 10 | |
| | 56 | 14 | | 3 12 | | 13 2<br>4 sand.<br>13 6 | 2 13 | 0 | 11 | |
| | 57 | 15 | | 3 12 | | 13 0<br>6 sand.<br>13 6 | 2 13 | 0 | 11 | |
| | 58 | 16 | | 3 12 | | 12 14<br>8 sand.<br>13 6 | 2 13 | 0 | 11 | |
| | 59 | 17 | | 3 12 | | 13 0<br>6 sand.<br>13 6 | 2 13 | 0 | 11 | |

*Watervleit Arsenal, at Sandy Hook, N. J., December 23, 1890.*

**with band 0.625 inch and 1.25 inches from base.]**

| Distance from center of target. | | | | Distance from center of impact. | | | | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|---|---|---|---|---|---|
| Vertical. | | Horizontal. | | Vertical. | | Horizontal. | | | |
| Above. | Below. | Right. | Left. | Above. | Below. | Right. | Left. | | |
| *Ft.* | *Ft.* | *Ft.* | *Ft.* | *Ft.* | *Ft.* | *Ft.* | *Ft.* | | |
| .... | 10½ | ...... | 8 | ...... | ...... | ...... | ...... | Gun mounted on Buffington steel field carriage (light), No. 17, with old spiral-spring brakes. De Bange gas-check. Fired from platform on fort wall. Fired at 1-mile target. Cannon friction primers (experimental), with modified priming, March, 1890. Aimed at bull's-eye. Telescopic sight used. | Sighting shot. |
| 6 | .... | ...... | ...... | ...... | ...... | ...... | ...... | | Sighting shot. |
| .... | .... | ...... | ...... | 1.20 | ...... | ...... | 6.375 | | |
| .... | 2 | ...... | 2 | ...... | .80 | ...... | 8.375 | | |
| .... | 3½ | 12½ | ...... | ...... | 2.30 | 6.125 | ...... | | |
| .... | 3 | 6½ | ...... | ...... | 1.80 | .125 | ...... | | |
| .... | 5 | 8½ | ...... | ...... | 3.80 | 2.125 | ...... | | |
| ½ | .... | 8½ | ...... | 1.70 | ...... | 2.125 | ...... | | |
| 4¾ | .... | 8½ | ...... | 5.95 | ...... | 2.125 | ...... | | |
| .... | 4 | 8 | ...... | ...... | 2.80 | 1.625 | ...... | | |
| 4¼ | .... | 6¼ | ...... | 5.45 | ...... | ...... | 1.25 | | |
| .... | 4 | 7 | ...... | ...... | 2.80 | .625 | ...... | | |

**Center of impact:** *Feet.*
Below ........................ 1.2
Right ........................ 6.375
**Mean vertical deviation from center of impact** .................. 2.86
**Mean horizontal deviation from center of impact** ................ 2.975
**Mean deviation from center of impact** .......................... 4.126
**Gun sighted by Lieut. O. M. Lissak, O. D. Target observed by Corpl. Maloney, ordnance detachment.**
**Firing conducted by the proof officer.**

*Record o*

| | No. of series. | No. of fire. | Powder. |
|---|---|---|---|
| | | | Kind. |
| P.M. | 60 | 18 | Du Pont's I. K. H. Lot 16. Density, 1,725. Granulation, 2,524. |
| | 61 | 19 | |
| | 62 | 20 | |
| | 63 | 21 | |
| | 64 | 22 | |
| | 65 | 23 | |
| | 66 | 24 | |
| | 67 | 25 | |
| | 68 | 26 | |
| | 69 | 27 | |
| | 70 | 28 | |

nal, *at Sandy Hook, N. J., December 29, 1890.*

nch and 1.25 inches from base.]

| cen- t. ntal. | | Distance from center of impact. | | | | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|---|---|---|---|
| | | Vertical. | | Horizontal. | | | |
| | *Left.* | Above. | Below. | Right. | Left. | | |
| | *Ft.* | *Ft.* | *Ft.* | *Ft.* | *Ft.* | | |
| | 5 | ...... | ...... | ...... | ...... | Gun mounted on Buffington steel field carriage (light), No. 17. De Bange gas-check. Wheels of carriage lashed to trail by rope. Fired from platform on fort wall. Fired at 1-mile target. Telescopic sight used. Cannon friction primers (experimental), with modified priming, March, 1890. | Sighting shot. |
| ...... | ...... | ...... | ...... | ...... | ...... | | Sighting shot. Struck 6 feet in front of target; ricochetted under. |
| .. | 2¼ | 3.875 | ...... | ...... | 0.65 | | |
| 4½ | ...... | 4.875 | ...... | 6.10 | ...... | | |
| ... | 2 | ...... | 1.125 | ...... | 0.40 | | |
| ... | ...... | ...... | 2.625 | 1.60 | ...... | | |
| ... | ...... | ...... | 0.125 | 1.60 | ...... | | |
| .... | 3 | ...... | 3.625 | ...... | 1.40 | | |
| ..... | 1¾ | ...... | 2.125 | ...... | 0.15 | | |
| ..... | 3½ | 2.875 | ...... | ...... | 1.90 | | |
| ..... | 2¼ | ...... | 3.875 | ...... | 0.65 | Fired at 1-mile target. | *Feet.*<br>Center of impact:<br>Above .......... 0.125<br>Left .......... 1.60<br>Mean vertical deviation from center of impact .......... 2.7<br>Mean horizontal deviation from center of impact .......... 1.86<br>Mean deviation from center of impact .......... 3.27<br>Gun sighted by Lieut. O. M. Lissak, O. D. Target observed by Corpl. T. Maloney, ordnance detachment.<br>Firing conducted by the proof officer. |
| ..... | 5¾ | 1.875 | ...... | ...... | 4.15 | | |

*Record of firing with 3.2-inch B. L. rifle (steel), No.*

[Object of firing, comparative test of 3.2-inch sh

|  | No. of series. | No. of fire. | Powder. |  | Projectile. |  | Elevation. | Wind allowance (points right). | Recoil. | Wind, strengt and di rection |
|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  | Kind. | Weight. | Kind. | Weight. |  |  |  |  |
|  |  |  |  | *Lbs. Oz.* |  | *Lbs. Oz.* | ° ' |  | *Feet.* |  |
| P. M. | ...... | 29 | Du Pont's I. K. H. Lot 16. Density, 1.725. Granulation, 2,524. | 3 12 | Shell re-banded. | 12 12<br>6 sand.<br>4 lead.<br>13 6 | 2 13 | ........ | 11⅛ | From rear and right, 16 miles an hour. |
|  | 71 | 30 |  | 3 12 | Shell (lot 297), with band ⅛ inch wide and 1.25 inches from base. | 12 15<br>7 sand.<br>13 6 | 2 15 | ........ | 11⅛ |  |
|  | 72 | 31 |  | 3 12 |  | 12 15<br>7 sand.<br>13 6 | 2 20 | ........ | 10 |  |
|  | 73 | 32 |  | 3 12 |  | 12 15<br>7 sand.<br>13 6 | 2 20 | ........ | 11 |  |
|  | 74 | 33 |  | 3 12 |  | 13 3<br>3 sand.<br>13 6 | 2 20 | ........ | 11 |  |
|  | 75 | 34 |  | 3 12 |  | 13 1<br>5 sand.<br>13 6 | 2 20 | ........ | 9 |  |
|  | 76 | 35 |  | 3 12 |  | 13 0<br>6 sand.<br>13 6 | 2 20 | ........ | 9 |  |
|  | 77 | 36 |  | 3 12 |  | 12 15<br>7 sand.<br>13 6 | 2 20 | ........ | 9 |  |
|  | 78 | 37 |  | 3 12 |  | 13 0<br>6 sand.<br>13 6 | 2 20 | ........ | 10 |  |
|  | 79 | 38 |  | 3 12 |  | 12 15<br>7 sand.<br>13 6 | 2 20 | ........ | 10 |  |
|  | 80 | 39 |  | 3 12 |  | 12 15<br>7 sand.<br>13 6 | 2 20 | ........ | 9 |  |
|  | 81 | 40 |  | 3 12 |  | 13 0<br>6 sand.<br>13 6 | 2 20 | ........ | 10 |  |

*Watervliet Arsenal, at Sandy Hook, N. J., December 29, 1890.*

**with band 0.625 inch and 1.25 inches from base.]**

| Distance from center of target. | | | | Distance from center of impact. | | | | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|---|---|---|---|---|---|
| Vertical | | Horizontal. | | Vertical. | | Horizontal. | | | |
| Above. | Below. | Right. | Left. | Above. | Below. | Right. | Left. | | |
| *Ft.* | *Ft.* | *Ft.* | *Ft.* | *Ft.* | *Ft.* | *Ft.* | *Ft.* | | |
| .... | 11½ | ...... | 5 | ...... | ...... | ...... | ...... | Gun mounted on Buffington steel field carriage (light), No. 17. De Bange gas-check. Wheels of carriage lashed to trail by rope. Fired from platform on fort wall. Fired at 1-mile target. Telescopic sight used. Cannon friction primers (experimental), with modified priming, March, 1890. | Sighting shot. |
| .... | .... | ...... | ...... | ...... | ...... | ...... | ...... | | Sighting shot. Struck 6 feet in front of target; ricochetted under. |
| 4 | .... | ...... | 2¼ | 3.875 | ...... | ...... | 0.65 | | |
| 5 | .... | 4½ | ...... | 4.875 | ...... | 6.10 | ...... | | |
| .... | 1 | ...... | 2 | ...... | 1.125 | ...... | 0.40 | | |
| .... | 2½ | ...... | ...... | ...... | 2.625 | 1.60 | ...... | | |
| .... | .... | ...... | ...... | ...... | 0.125 | 1.60 | ...... | | |
| .... | 3½ | ...... | 3 | ...... | 3.625 | ...... | 1.40 | | |
| .... | 2 | ...... | 1¾ | ...... | 2.125 | ...... | 0.15 | | |
| 3 | .... | ...... | 3½ | 2.875 | ...... | ...... | 1.90 | | |
| .... | 3¾ | ...... | 2¼ | ...... | 3.875 | ...... | 0.65 | Fired at 1-mile target. | *Feet.*<br>Center of impact:<br>Above ........ 0.125<br>Left ........ 1.60<br>Mean vertical deviation from center of impact ........ 2.7<br>Mean horizontal deviation from center of impact ........ 1.86<br>Mean deviation from center of impact ........ 3.27<br>Gun sighted by Lieut. O. M. Lissak, O. D. Target observed by Corpl. T. Maloney, ordnance detachment.<br>Firing conducted by the proof officer. |
| 2 | .... | ...... | 5¾ | 1.875 | ...... | ...... | 4.15 | | |

*Record of firing with 3.2-inch B. L. rifle (steel), No. 26, Watervli*

[Object of firing, comparative test of 3. 2-inch shel

| | No. of series. | No. of fire. | Powder. | | Projectile. | | Elevation. | Wind allowance (points right). | Recoil. | Wind, strength and direction. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | | | |
| | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ′ | | *Feet.* | |
| P. M. | 82 | 41 | Du Pont's I. K. H. Lot 16. Density 1.725. Granulation, 2,524. | 3 12 | Shell (lot 284), with band ⅝ inch wide and ⅜ inch from base. | 12 15<br>7 sand.<br>13 6 | 2 25 | ½ | 10 | From rear and right, 16 miles an hour. |
| | 83 | 42 | | 3 12 | | 13 1<br>5 sand.<br>13 6 | 2 27 | ½ | 9 | |
| | 84 | 43 | | 3 12 | | 13 0<br>6 sand.<br>13 6 | 2 27 | ½ | 10 | |
| | 85 | 44 | | 3 12 | | 13 1<br>5 sand.<br>13 6 | 2 27 | ½ | 9 | |
| | 86 | 45 | | 3 12 | | 12 15<br>7 sand.<br>13 6 | 2 27 | ½ | 9 | |
| | 87 | 46 | | 3 12 | | 13 1<br>5 sand.<br>13 6 | 2 27 | ½ | 9 | |
| | 88 | 47 | | 3 12 | | 13 0<br>6 sand.<br>13 6 | 2 27 | ½ | 9 | |
| | 89 | 48 | | 3 12 | | 13 2<br>4 sand.<br>13 6 | 2 27 | ½ | 9 | |
| | 90 | 49 | | 3 12 | | 13 3<br>3 sand.<br>13 6 | 2 27 | ½ | 9 | |
| | 91 | 50 | | 3 12 | | 12 15<br>7 sand.<br>13 6 | 2 27 | ½ | 9 | |
| | 92 | 51 | | 3 12 | | 13 2<br>4 sand.<br>13 6 | 2 27 | ½ | 9 | |

*Arsenal, at Sandy Hook, N. J., December 29, 1890*—Continued.

**with band 0.625 inch and 1.25 inches from base.]**

| Distance from center of target. | | | | Distance from center of impact. | | | | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|---|---|---|---|---|---|
| Vertical. | | Horizontal. | | Vertical. | | Horizontal. | | | |
| Above. | Below. | Right. | Left. | Above. | Below. | Right. | Left. | | |
| Ft. | Ft. | Ft. | Ft. | Ft. | Ft. | Ft. | Ft. | | |
| .... | 6 | ...... | 9.25 | ...... | ...... | ...... | ...... | Gun mounted on Buffington steel field carriage (light), No. 17. De Bange gas-check. Wheels of carriage lashed to trail by rope. Fired from platform on fort wall. Fired at 1-mile target. Telescopic sight used. Cannon friction primers (experimental), with modified priming. | Sighting shot. |
| .... | 1 | ...... | 11 | ...... | 2.80 | ...... | 3.05 | | |
| 3 | .... | ...... | 10.50 | 1.20 | ...... | ...... | 2.55 | | |
| .... | 2.75 | ...... | 12.25 | ...... | 4.55 | ...... | 4.30 | | First primer failed. |
| 2.50 | .... | ...... | 7 | .70 | ...... | .95 | ...... | | |
| .... | 2 | 2 | ...... | ...... | 3.80 | 9.95 | ...... | | |
| 9.50 | .... | ...... | 9.75 | 7.70 | ...... | ...... | 1.80 | | |
| 2.75 | .... | ...... | 7 | .95 | ...... | .95 | ...... | | |
| 1.25 | .... | ...... | 11 | ...... | .55 | ...... | 3.05 | | |
| .75 | .... | ...... | 5 | ...... | 1.05 | 2.95 | ...... | | |
| 4 | .... | ...... | 8 | 2.20 | ...... | ...... | .05 | | |

| | Feet. |
|---|---|
| Center of impact: | |
| Above | 1.80 |
| Left | 7.95 |
| Mean vertical deviation from center of impact | 2.55 |
| Mean horizontal deviation from center of impact | 2.96 |
| Mean deviation from center of impact | 3.9 |

Gun sighted by Lieut. O. M. Lissak, O. D. Target observed by Corpl. Maloney, ordnance detachment.

Firing conducted by the proof officer.

*Record of firing with 3.2-inch B. L. rifle (steel), No. 26,*

[Object of firing, comparative test of 3.2-inch shell,

| Date. | | No. of series. | No. of fire. | Powder. Kind. | Powder. Weight. | Projectile. Kind. | Projectile. Weight. | Elevation. | Wind allowances (points left). | Recoil. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° " | | *Feet.* |
| Dec. 30 | P.M. | | 52 | Du Pont's I. K. H. Lot 16. Density, 1.725. Granulation, 2,524. | 3 12 | Shell rebanded. | 12 11<br>7 sand.<br>4 lead.<br>13 6 | 5 15 | ⅛ | 10 |
| | | | 53 | | 3 12 | | 12 7<br>7 sand.<br>8 lead.<br>13 6 | 5 5 | ⅛ | 10 |
| | | | 54 | | 3 12 | | 12 7<br>8 sand.<br>7 lead.<br>13 6 | 5 00 | 0 | 10 |
| | | | 55 | | 3 12 | | 12 10<br>7 sand.<br>5 lead.<br>13 6 | 4 55 | ⅜ | 10 |
| | | | 56 | | 3 12 | | 12 7<br>8 sand.<br>7 lead.<br>13 6 | 4 50 | 1 | 10 |
| | | | 57 | | 3 12 | | 12 14<br>6 sand.<br>2 lead.<br>13 6 | 4 40 | 1⅓ | 10 |
| | | | 58 | | 3 12 | | 12 14<br>8 sand.<br>13 6 | 4 25 | 1¾ | 10 |
| | | | 59 | | 3 12 | Shell (lot 297), with band ⅛ inch wide and 1.25 inches from base. | 13 00<br>6 sand.<br>13 6 | 4 35 | 2 | 10 |
| | | | 60 | | 3 12 | | 13 00<br>6 sand.<br>13 6 | 4 50 | 2⅛ | 10 |
| | | | 61 | | 3 12 | | 13 00<br>6<br>13 6 | 5 5 | 2⅛ | 10 |
| | | | 62 | | 3 12 | | 12 15<br>7<br>13 6 | 5 15 | 3 | 10 |
| | | | 63 | | 3 12 | | 12 15<br>7<br>13 6 | 5 25 | 3 | 10 |

*Watervliet Arsenal, at Sandy Hook, N. J., December 30, 1890.*

**with band 0.625 inch and 1.25 inches from base.]**

| Wind, strength and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|
| | Gun mounted on Buffington steel field carriage (light), No. 17. Wheels of carriage lashed to trail by rope. Cannon friction primers (experimental), with modified priming, March, 1890. Telescopic sight used. | |
| From rear and right, 18 miles an hour. | Fired at 3,000-yards target. Aimed at upper left-hand corner. | Sighting shot. Struck ground 300 yards in rear of target. |
| | | Sighting shot. Struck ground 50 feet to the left and 200 yards in rear of target. |
| | | Sighting shot. Miss to the right. |
| | | Sighting shot. Miss to the right. |
| | | Sighting shot. Struck ground 1,000 yards in rear of target. |
| | | Sighting shot. Struck ground 260 yards in front and 70 yards to the right of target. |
| | | Sighting shot. Struck ground 200 yards in front of target. |
| | | Sighting shot. Struck ground 200 yards in front of target. |
| | | Sighting shot. Struck ground about 120 yards in front and 50 feet to the right of target. |
| | | Sighting shot. Struck ground 30 yards in front and in line with right edge of target. |
| | | Sighting shot. Struck ground 50 feet in front; ricochetted through target 8 feet above bull's-eye. |
| | | Sighting shot. Struck ground 30 feet in rear and 10 feet to the left of target. |
| | Fall of shot at target not correctly reported at gun.<br>Gun sighted by Lieut. O. M. Lissak, O. D. Target observed by Corpl. Maloney, ordnance detachment.<br>Firing conducted by the proof officer. | |

*Record of firing with 3.2-inch B. L. rifle (steel), No. 26, Watervliet*

[Object of firing, comparative test of 3.2-inch shell.

| Date. | | No. of series. | No. of fire. | Powder. | | Projectile. | | Elevation. | Wind allowances (points left). | Recoil. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Kind. | Weight. | Kind. | Weight. | | | |
| | | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ′ | *Left.* | *Feet.* |
| Jan. 6 | P. M. | ...... | 64 | Du Pont's I. K. H. Lot 16. Density, 1.725. Granulation, 2,524. | 3 12 | Shell rebanded. | 12 6<br>10 sand.<br>13 0 | 5 20 | 1 | 10 |
| | | ...... | 65 | | 3 12 | | 12 13<br>4 sand,<br>5 lead.<br>13 6 | 5 30 | 0 | 10 |
| | | ...... | 66 | | 3 12 | | 12 12<br>10 sand.<br>13 6 | 5 40 | *Right.*<br>½ | 10 |
| | | 98 | 67 | | 3 12 | Shell (lot 297), with band ¼ inch wide and 1.25 inches from base. | 12 15<br>7 sand.<br>13 6 | 5 40 | 1 | 10 |
| | | 99 | 69 | | 3 12 | | 13 0<br>6 sand.<br>13 6 | 5 35 | 2 | 10 |
| Jan. 14 | A. M. | 100 | 73 | Du Pont's I. K. H. Lot 16. Density, 1.725. Granulation, 2,524. | 3 12 | Shell rebanded. | 12 12<br>10 sand.<br>13 6 | 5 18 | *Left.*<br>1 | 9 |
| | | 101 | 74 | | 3 12 | | 12 13<br>9 sand.<br>13 6 | 5 25 | ¼ | 8 |
| | | 102 | 75 | | 3 12 | | 13 0<br>6 sand.<br>13 6 | 5 40 | 0 | 9 |
| | | 103 | 76 | | 3 12 | | 12 12<br>10 sand.<br>13 6 | 5 35 | *Right.*<br>1 | 9 |
| | | 104 | 77 | | 3 12 | Shell (lot 297), with band ¼ inch wide and 1.25 inches from base. | 13 0<br>6 sand.<br>13 6 | 5 40 | ¼ | 9 |
| Jan. 14 | P. M. | 105 | 78 | | 3 12 | Shell rebanded. | 12 12<br>10 sand.<br>13 6 | 5 37 | ¾ | 8 |
| | | 106 | 79 | | 3 12 | | 12 12<br>10 sand.<br>13 6 | 5 37 | 1½ | 8 |

*Arsenal at Sandy Hook, N. J., from January 6 to January 14, 1891.*

**with band 0.625 inch and 1.25 inches from base.**

| Wind, strength and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|
| | Gun mounted on Buffington steel field carriage (light), No. 17. Wheels lashed to trail by rope. Cannon friction primers (experimental), with modified priming, March, 1890. Telescopic sight used. | |
| From rear and right, 24 miles per hour. | Fired at 3,000-yards target. Aimed at upper left-hand corner. | Sighting shot. Struck 70 yards in front and 50 feet to left of target. |
| | | Sighting shot. Struck 25 yards in front and to left of target. |
| | | Sighting shot. Struck 100 yards beyond and to left of target. |
| | | Sighting shot. Struck 200 yards beyond and to left of target. |
| | | Sighting shot. Struck 150 yards beyond and to right of target. |
| | Cannon friction primers (experimental), with spiral serrated wire, March 1890. | |
| From right and rear, 23 miles an hour. | Fired at 3,000-yards target. Aimed at upper left edge of target. | Sighting shot. Struck 150 yards in front and to left of target. |
| | | Sighting shot. Struck 70 yards in front and in line with left edge of target. |
| | | Sighting shot. Struck 100 yards beyond and to left of target. |
| | | Sighting shot. Struck 20 yards in front and to right of target. |
| | | Struck 150 yards beyond target. |
| | | Sighting shot. Struck 50 yards beyond and 16 yards to left of target. |
| | | Sighting shot. Struck 100 yards beyond and 50 feet to left of target. |
| | Gun sighted by Lieut. O. M. Lissak, O. D. Target observed by Corpl. I. Alward, ordnance detachment.<br>Firing conducted by the proof officer. | |

*Record of firing with 3.2-inch B. L. rifle (steel), No. 26, Watervliet*

[Object of firing, comparative test of 3.2-inch shell.

| Date. | | No. of series. | No. of fire. | Powder. | | Projectile. | | Elevation. | Wind allowances (points left). | Recoil. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Kind. | Weight. | Kind. | Weight. | | | |
| | | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ′ | | *Feet.* |
| Jan. 14 | P. M. | 107 | 80 | Du Pont's I. K. H. Lot 16. Density, 1.725. Granulation, 2,524. | 3 12 | Shell rebanded. | 12 6<br>1 0 sand.<br>13 6 | 5 35 | 1⅜ | 8 |
| | | 108 | 81 | | 3 12 | | 13 0<br>6 sand.<br>13 6 | 5 37 | 1⅜ | 8 |
| | | 109 | 82 | | 3 12 | Shell (lot 297) with band ½ inch wide and 1.25 inches from base. | 13 1<br>5 sand.<br>13 6 | 5 37 | 1⅜ | 8 |
| | | 110 | 83 | | 3 12 | | 13 0<br>6 sand.<br>13 6 | 5 37 | 1⅜ | 8 |
| | | 111 | 84 | | 3 12 | | 13 0<br>6 sand.<br>13 6 | 5 36 | 1⅜ | 9 |
| | | 112 | 85 | | 3 12 | | 13 0<br>6 sand.<br>13 6 | 5 33 | 1⅜ | 9 |
| | | 113 | 86 | | 3 12 | | 13 1<br>5 sand.<br>13 6 | 5 28 | 1⅜ | 9 |
| | | 114 | 87 | | 3 12 | | 13 0<br>6 sand.<br>13 6 | 5 28 | 1⅜ | 9 |
| | | 115 | 88 | | 3 12 | | 13 2<br>4 sand.<br>13 6 | 5 25 | 1⅜ | 9 |
| | | 116 | 89 | | 3 12 | | 13 0<br>6 sand.<br>13 6 | 5 23 | 1⅜ | 9 |
| | | 117 | 90 | | 3 12 | | 13 0<br>6 sand.<br>13 6 | 5 20 | 1⅜ | 9 |
| | | 118 | 91 | | 3 12 | | 12 15<br>7 sand.<br>13 6 | 5 20 | 1⅜ | 9 |
| | | 119 | 92 | | 3 12 | | 13 0<br>6 sand.<br>13 6 | 5 18 | 1⅜ | 9 |
| | | 120 | 93 | | 3 12 | Shell (lot 284), with band ½ inch wide and 0.625 inch from base. | 13 0<br>6 sand.<br>13 6 | 5 30 | 1⅜ | 9 |
| | | 121 | 94 | | 3 12 | | 12 14<br>8 sand.<br>13 6 | 5 30 | 1⅜ | 9 |

*Arsenal, at Sandy Hook, N. J., January 14, 1890*—Continued.

**with band 0.625 inch and 1.25 inches from base.]**

| Wind, strength and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|
| From right and rear, 23 miles an hour. | Gun mounted on Buffington steel field-carriage (light), No, 17. Wheels lashed to trail by rope. Cannon friction primers (experimental), with spiral serrated wire, March, 1890.<br>Fired at 3,000-yards target. Aimed at upper left edge of target. | Sighting shot. Struck 14 yards in front and 4 feet left of line. |
| | | Struck target 8 feet above and 1 foot left of center. |
| | Old spiral-spring brakes.<br>Fired at 3,000-yards target. Aimed at upper left corner of target. | Struck 275 yards beyond and 6 feet to left of target. |
| | | Struck 250 yards beyond and 6 feet to right of target. |
| | | First primer failed. Struck 252 yards beyond and 12 feet to right of target. |
| | | Struck 251 yards beyond and 5 feet to right of target. |
| | | Struck target 9 feet above and 11 feet left of center. |
| | | Struck 235 yards in rear and 4 feet to left of target. |
| | | Struck 112 yards beyond and 10 feet to left of target. |
| | | Struck 100 yards beyond and 6 feet to right of target. |
| | | Struck target 11 feet right and 4 feet above center. |
| | | Struck 112 yards beyond and 12 feet to right of target. |
| | Fired at 3,000-yards target | Struck 120 yards beyond target and 10 feet right. |
| | | Struck target 7 feet below and 7 feet right of center. |
| | | Struck 47 yards beyond and 8 feet to right of target. |
| | Gun sighted by Lieut. O. M. Lissak, O. D. Target observed by Corpl. Alward, ordnance detachment. Firing conducted by the proof officer. | |

*Record of firing with 3.2-inch B. L. rifle (steel), No. 26,*

**[Object of firing, comparative test of 3.2-inch shell,**

|  | No. of series. | No. of fire. | Powder. |  | Projectile. |  | Elevation. | Wind allowance (points). | Recoil. | Wind, strength and direction. |
|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  | Kind. | Weight. | Kind. | Weight. |  |  |  |  |
|  |  |  |  | *Lbs. Oz.* |  | *Lbs. Oz.* | ° ′ | *Right.* | *Feet.* |  |
| P. M. | 122 | 95 | Du Pont's I. K. H. Lot 16. Density, 1.725. Granulation, 2,524. | 3 12 | Shell (lot 284), with band ½ inch wide and 0.625 inch from base. | 12 15<br>7 sand.<br>13 6 | 5 28 | ½ | 9 | From right, 12 miles an hour. |
|  | 123 | 96 |  | 3 12 |  | 12 15<br>7 sand.<br>13 6 | 5 30 | *Left.*<br>½ | 9 |  |
|  | 124 | 97 |  | 3 12 |  | 13 1<br>5 sand.<br>13 6 | 5 32 | 1½ | 9 |  |
|  | 125 | 98 |  | 3 12 |  | 13 1<br>5 sand.<br>13 6 | 5 38 | 2 | 9 |  |
|  | 126 | 99 |  | 3 12 |  | 13 1<br>5 sand.<br>13 6 | 5 43 | 2 | 9 |  |
|  | 127 | 100 |  | 3 12 |  | 12 15<br>7 sand.<br>13 6 | 5 45 | 2 | 9 |  |
|  | 128 | 101 |  | 3 12 |  | 13 0<br>6 sand.<br>13 6 | 5 45 | 2 | 9 |  |
|  | 129 | 102 |  | 3 12 |  | 13 1<br>5 sand.<br>13 6 | 5 45 | 2 | 9 |  |
|  | 130 | 103 |  | 3 12 |  | 13 2<br>4 sand.<br>13 6 | 5 45 | 2 | 9 |  |
|  | 131 | 104 |  | 3 12 |  | 13 0<br>6 sand.<br>13 6 | 5 45 | 2 | 9 |  |
|  | 132 | 105 |  | 3 12 |  | 13 0<br>6 sand.<br>13 6 | 5 45 | 2 | 9 |  |
|  | 133 | 106 |  | 3 12 |  | 13 2<br>4 sand.<br>13 6 | 5 45 | 2 | 9 |  |

*Watervliet Arsenal, at Sandy Hook, N. J., January 15, 1891.*

**with band 0.625 inch and 1.25 inches from base.]**

| Distance from center of target. | | | | Distance from center of impact. | | | | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|---|---|---|---|---|---|
| Vertical | | Horizontal. | | Vertical. | | Horizontal. | | | |
| Above. | Below. | Right. | Left. | Above. | Below. | Right. | Left. | | |
| Ft. | Ft. | Ft. | Ft. | Ft. | Ft. | Ft. | Ft. | | |
| .... | .... | .... | .... | .... | .... | .... | .... | Gun mounted on Buffington steel field carriage (light), No. 17, with old spiral-spring brakes. Cannon friction primers (experimental), with spiral serrated wire, March, 1890. Fired at 3,000-yards target. Telescopic sight used. Aimed at upper left-hand corner of target. | Sighting shot. Struck 16 yards in front and 15 yards to right of target. |
| .... | .... | .... | .... | .... | .... | .... | .... | | Sighting shot. Struck 41 yards in front and 10 yards to right of target. |
| .... | .... | .... | .... | .... | .... | .... | .... | | Sighting shot. Struck 48 yards in front and 10 yards to right of target. |
| .... | .... | .... | .... | .... | .... | .... | .... | | Sighting shot. Struck 21 yards in front and ricochetted through target 10½ feet left and 5 feet above center. |
| .... | 15 | ⅛ | .... | .... | .... | .... | .... | | Sighting shot. |
| .... | .... | .... | 8 | .... | .125 | 4.16 | .... | | |
| .... | 1½ | .... | 14 | .... | 1.625 | .... | 1.84 | | |
| .... | .... | .... | .... | .... | .... | .... | .... | | Miss. Struck 60 yards beyond and 12 yards to left of target. |
| .... | 2 | .... | 9 | .... | 2.125 | 3.16 | .... | | |
| 3½ | .... | .... | 16 | 3.375 | .... | .... | 3.84 | | |
| 1 | .... | .... | 19 | .875 | .... | .... | 6.84 | | |
| .... | ¼ | .... | 7 | .... | .375 | 5.16 | .... | | |

*Record of firing with 3.2-inch B. L. rifle (steel), No. 26, Watervliet*

[Object of firing, comparative test of 3.2-inch shell,

| | No. of series. | No. of fire. | Powder. Kind. | Powder. Weight. | Projectile. Kind. | Projectile. Weight. | Elevation. | Wind allowance (points). | Recoil. | Wind, strength and direction. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ′ | *Right.* | *Feet.* | |
| P. M. | 134 | 107 | Du Pont's I. K. H. Lot 16. Density, 1.725. Granulation, 2.524. | 3 12 | Shell (lot 284), with band ¾ inch wide and 0.625 inch from base. | 13 4<br>2 sand.<br>13 6 | 5 45 | 2 | 9 | From right, 12 miles an hour. |
| | 135 | 108 | | 3 12 | | 13 2<br>4 sand.<br>13 6 | 5 45 | 2 | 9 | |
| | 136 | 109 | | 3 12 | | 13 0<br>6 sand.<br>13 6 | 5 45 | 2 | 9 | |
| | 137 | 110 | Du Pont's I. K. H. Lot 16. Density, 1.725. Granulation, 2,525. | 3 12 | Shell (lot 297), with band ¾ inch wide and 1.25 inches from base. | 12 15<br>7 sand.<br>13 6 | 5 25 | 1¾ | 9 | From right, 9 miles an hour. |
| | 138 | 111 | | 3 12 | | 13 1<br>5 sand.<br>13 6 | 5 25 | 1¾ | 9 | |
| | 139 | 112 | | 3 12 | | 13 2<br>4 sand.<br>13 6 | 5 25 | 1¾ | 9 | |
| | 140 | 113 | | 3 12 | | 12 14<br>8 sand.<br>13 6 | 5 25 | 1¾ | 9 | |
| | 141 | 114 | | 3 12 | | 13 0<br>6 sand.<br>13 6 | 5 25 | 1¾ | 9 | |
| | 142 | 115 | | 3 12 | | 12 15<br>7 sand.<br>13 6 | 5 25 | 1¾ | 9 | |

*Arsenal, at Sandy Hook, N. J., January 15, 1891*—Continued.

**with band 0.625 inch and 1.25 inches from base.]**

| Distance from center of target. | | | | Distance from center of impact. | | | | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|---|---|---|---|---|---|
| Vertical | | Horizontal. | | Vertical. | | Horizontal. | | | |
| Above. | Below. | Right. | Left. | Above. | Below. | Right. | Left. | | |
| *Ft.* | *Ft.* | *Ft.* | *Ft.* | *Ft.* | *Ft.* | *Ft.* | *Ft.* | | |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Fired at 3,000-yards target. | Miss. Struck 50 yards in rear and 5 yards to left of target. |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | | Miss. Struck 78 yards in rear and in line with left edge of target. |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | | Miss. Struck 88 yards in rear and in line with left edge of target. |
| Gun sighted by Lieut O. M. Lissak, O. D. Target observed by Corpl. Maloney, ordnance detachment. | | | | | | | | | Center of impact: *Feet.*<br>Above 0.125<br>Left 12.16<br>Mean vertical deviation from center of impact 1.416<br>Mean horizontal deviation from center of impact 4.173<br>Mean deviation from center of impact 4.406 |
| 7½ | ..... | ..... | 7 | 12.2 | ..... | 2.35 | ..... | Gun mounted on Buffington steel field carriage (light), No. 17, with old spiral-spring brakes. Cannon friction primers (experimental), with spiral serrated wire, March, 1890. Fired at 3,000-yards target. Telescopic sight used. Aimed at upper left-hand corner of target. | |
| ..... | 6½ | ..... | 2½ | ..... | 1.8 | 6.85 | ..... | | |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | | Struck 6 feet in front and passed under center of target. |
| ..... | 14 | ..... | 16 | ..... | 9.3 | ..... | 6.65 | | |
| 1½ | ..... | ..... | 11¼ | 6.2 | ..... | ..... | 1.90 | | |
| ..... | 12 | ..... | 10 | ..... | 7.3 | ..... | .65 | | |
| Gun sighted by Lieut. O. M. Lissak, O. D. Target observed by Corpl. Maloney, ordnance detachment.<br>Firing conducted by the proof officer. | | | | | | | | | Wind dropped from 12 miles an hour at 1 o'clock to 9 miles an hour at 4 o'clock.<br>Center of impact: *Feet.*<br>Below 4.7<br>Left 9.35<br>Mean vertical deviation from center of impact 7.36<br>Mean horizontal deviation from center of impact 3.68<br>Mean deviation from center of impact 8.22 |

8

N. J.

ber 22nd 1890.

*Misses,* 1

2.456 ft.

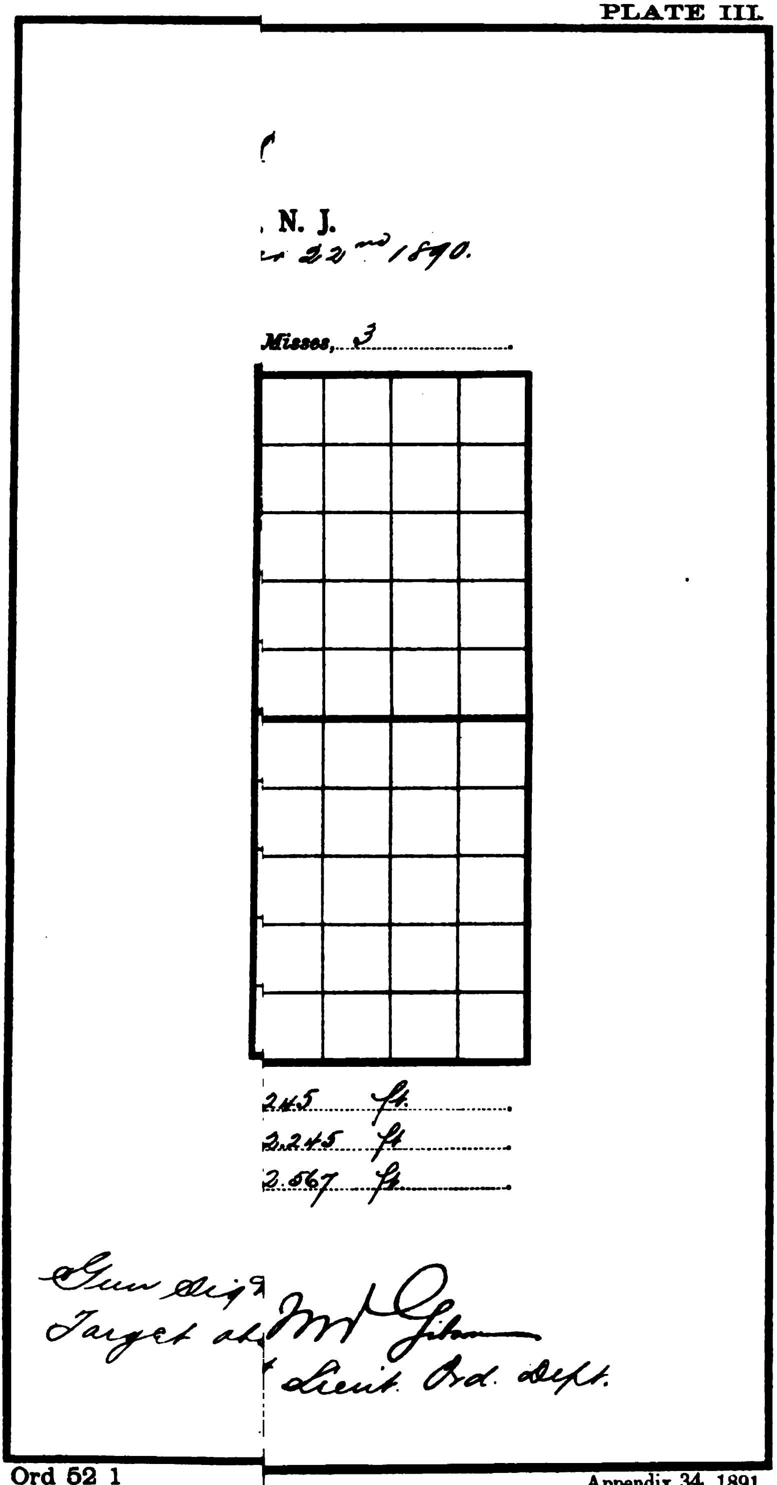
1.531 ft.

2.894 ft.

Gen Ser

Target at Gibm

t. Ord Dept.



, N. J.

r 22nd 1890.

Misses, 3

245 ft.

2.245 ft

2.567 ft

Gun Dep'd

Target at

McGibbon

t Lieut. Ord. Dept.

*Record of firing with 3.2-inch B. L. rifle (steel), No.*

**[Object of firing, comparative test of 3.2-inch shell**

| Date. | | No. of series. | No. of fire. | Powder. | | Projectile. | | Elevation. | Wind allowances (points left). | Recoil |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Kind. | Weight. | Kind. | Weight. | | | |
| | | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ″ | | *Feet.* |
| Dec. 30 | P.M. | | 52 | Du Pont's I. K. H. Lot 16. Density, 1.725. Granulation, 2.524. | 3 12 | Shell rebanded. | 12 11<br>7 sand.<br>4 lead.<br>13 6 | 5 15 | ½ | 10 |
| | | | 53 | | 3 12 | | 12 7<br>7 sand.<br>8 lead.<br>13 6 | 5 5 | ½ | 10 |
| | | | 54 | | 3 12 | | 12 7<br>8 sand.<br>7 lead.<br>13 6 | 5 00 | 0 | 10 |
| | | | 55 | | 3 12 | | 12 10<br>7 sand.<br>5 lead.<br>13 6 | 4 55 | ¾ | 10 |
| | | | 56 | | 3 12 | | 12 7<br>8 sand.<br>7 lead.<br>13 6 | 4 50 | 1 | 10 |
| | | | 57 | | 3 12 | | 12 14<br>6 sand.<br>2 lead.<br>13 6 | 4 40 | 1¼ | 10 |
| | | | 58 | | 3 12 | | 12 14<br>8 sand.<br>13 6 | 4 25 | 1¾ | 10 |
| | | | 59 | | 3 12 | Shell (lot 297), with band ½ inch wide and 1.25 inches from base. | 13 00<br>6 sand.<br>13 6 | 4 35 | 2 | 10 |
| | | | 60 | | 3 12 | | 13 00<br>6 sand.<br>13 6 | 4 50 | 2¼ | 10 |
| | | | 61 | | 3 12 | | 13 00<br>6<br>13 6 | 5 5 | 2½ | 10 |
| | | | 62 | | 3 12 | | 12 15<br>7<br>13 6 | 5 15 | 3 | 10 |
| | | | 63 | | 3 12 | | 12 15<br>7<br>13 6 | 5 25 | 3 | 10 |

*Watervliet Arsenal, at Sandy Hook, N. J., December 30, 1890.*

**with band 0.625 inch and 1.25 inches from base.]**

| Wind, strength and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|
| | Gun mounted on Buffington steel field carriage (light), No. 17. Wheels of carriage lashed to trail by rope. Cannon friction primers (experimental), with modified priming, March, 1890. Telescopic sight used. | |
| From rear and right, 18 miles an hour. | Fired at 3,000-yards target. Aimed at upper left-hand corner. | Sighting shot. Struck ground 300 yards in rear of target. |
| | | Sighting shot. Struck ground 50 feet to the left and 200 yards in rear of target. |
| | | Sighting shot. Miss to the right. |
| | | Sighting shot. Miss to the right. |
| | | Sighting shot. Struck ground 1,000 yards in rear of target. |
| | | Sighting shot. Struck ground 260 yards in front and 70 yards to the right of target. |
| | | Sighting shot. Struck ground 200 yards in front of target. |
| | | Sighting shot. Struck ground 200 yards in front of target. |
| | | Sighting shot. Struck ground about 120 yards in front and 50 feet to the right of target. |
| | | Sighting shot. Struck ground 30 yards in front and in line with right edge of target. |
| | | Sighting shot. Struck ground 50 feet in front; ricochetted through target 8 feet above bull's-eye. |
| | | Sighting shot. Struck ground 30 feet in rear and 10 feet to the left of target. |
| | Fall of shot at target not correctly reported at gun.<br>Gun sighted by Lieut. O. M. Lissak, O. D. Target observed by Corpl. Maloney, ordnance detachment.<br>Firing conducted by the proof officer. | |

*Record of firing with 3.2-inch B. L. rifle (steel), No. 26, Watervliet*

[Object of firing, comparative test of 3.2-inch shell,

| Date. | | No. of series. | No. of fire. | Powder. | | Projectile. | | Elevation. | Wind allowances (points left). | Recoil. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Kind. | Weight. | Kind. | Weight. | | | |
| | | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ′ | *Left.* | *Feet* |
| Jan. 6 | P. M. | ...... | 64 | Du Pont's I. K. H. Lot 16. Density, 1.725. Granulation, 2,524. | 3 12 | Shell rebanded. | 12 6<br>10 sand.<br>13 0 | 5 20 | 1 | 10 |
| | | ...... | 65 | | 3 12 | | 12 13<br>4 sand,<br>5 lead.<br>13 6 | 5 30 | 0 | 10 |
| | | ...... | 66 | | 3 12 | | 12 12<br>10 sand.<br>13 6 | 5 40 | *Right.*<br>½ | 10 |
| | | 98 | 67 | | 3 12 | Shell (lot 297), with band ½ inch wide and 1.25 inches from base. | 12 15<br>7 sand.<br>13 6 | 5 40 | 1 | 10 |
| | | 99 | 69 | | 3 12 | | 13 0<br>6 sand.<br>13 6 | 5 35 | 2 | 10 |
| Jan. 14 | A. M. | 100 | 73 | Du Pont's I. K. H. Lot 16. Density, 1.725. Granulation, 2,524. | 3 12 | Shell rebanded. | 12 12<br>10 sand.<br>13 6 | 5 18 | *Left.*<br>1 | 9 |
| | | 101 | 74 | | 3 12 | | 12 13<br>9 sand.<br>13 6 | 5 25 | ½ | 8 |
| | | 102 | 75 | | 3 12 | | 13 0<br>6 sand.<br>13 6 | 5 40 | 0 | 9 |
| | | 103 | 76 | | 3 12 | | 12 12<br>10 sand.<br>13 6 | 5 35 | *Right.*<br>1 | 9 |
| | | 104 | 77 | | 3 12 | Shell (lot 297), with band ½ inch wide and 1.25 inches from base. | 13 0<br>6 sand.<br>13 6 | 5 40 | ½ | 9 |
| Jan. 14 | P. M. | 105 | 78 | | 3 12 | Shell rebanded. | 12 12<br>10 sand.<br>13 6 | 5 37 | ¾ | 8 |
| | | 106 | 79 | | 3 12 | | 12 12<br>10 sand.<br>13 6 | 5 37 | 1¼ | 8 |

*Arsenal at Sandy Hook, N. J., from January 6 to January 14, 1891.*

**with band 0.625 inch and 1.25 inches from base.**

| Wind, strength and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|
| | Gun mounted on Buffington steel field carriage (light), No. 17. Wheels lashed to trail by rope. Cannon friction primers (experimental), with modified priming, March, 1890. Telescopic sight used. | |
| From rear and right, 24 miles per hour. | Fired at 3,000-yards target. Aimed at upper left-hand corner. | Sighting shot. Struck 70 yards in front and 50 feet to left of target. |
| | | Sighting shot. Struck 25 yards in front and to left of target. |
| | | Sighting shot. Struck 100 yards beyond and to left of target. |
| | | Sighting shot. Struck 200 yards beyond and to left of target. |
| | | Sighting shot. Struck 150 yards beyond and to right of target. |
| | Cannon friction primers (experimental), with spiral serrated wire, March 1890. | |
| From right and rear, 23 miles an hour. | Fired at 3,000-yards target. Aimed at upper left edge of target. | Sighting shot. Struck 150 yards in front and to left of target. |
| | | Sighting shot. Struck 70 yards in front and in line with left edge of target. |
| | | Sighting shot. Struck 100 yards beyond and to left of target. |
| | | Sighting shot. Struck 20 yards in front and to right of target. |
| | | Struck 150 yards beyond target. |
| | | Sighting shot. Struck 50 yards beyond and 16 yards to left of target. |
| | | Sighting shot. Struck 100 yards beyond and 50 feet to left of target. |
| | Gun sighted by Lieut. O. M. Lissak, O. D.<br>Target observed by Corpl. I. Alward, ordnance detachment.<br>Firing conducted by the proof officer. | |

*Record of firing with 3.2-inch B. L. rifle (steel), No. 26, Waterrliet*

[Object of firing, comparative test of 3.2-inch shell,

| Date. | | No. of series. | No. of fire. | Powder. | | Projectile. | | Elevation. | Wind allowances (points left). | Recoil. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Kind. | Weight. | Kind. | Weight. | | | |
| | | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ′ | | *Feet.* |
| Jan. 14 | P.M. | 107 | 80 | Du Pont's I. K. H. Lot 16. Density, 1.725. Granulation, 2,524. | 3 12 | Shell rebanded. | 12 6<br>1 0 sand.<br>13 6 | 5 35 | 1⅜ | 8 |
| | | 108 | 81 | | 3 12 | | 13 0<br>6 sand.<br>13 6 | 5 37 | 1⅜ | 8 |
| | | 109 | 82 | | 3 12 | Shell (lot 297) with band ½ inch wide and 1.25 inches from base. | 13 1<br>5 sand.<br>13 6 | 5 37 | 1⅜ | 8 |
| | | 110 | 83 | | 3 12 | | 13 0<br>6 sand.<br>13 6 | 5 37 | 1⅜ | 8 |
| | | 111 | 84 | | 3 12 | | 13 0<br>6 sand.<br>13 6 | 5 36 | 1⅜ | 9 |
| | | 112 | 85 | | 3 12 | | 13 0<br>6 sand.<br>13 6 | 5 33 | 1⅜ | 9 |
| | | 113 | 86 | | 3 12 | | 13 1<br>5 sand.<br>13 6 | 5 28 | 1⅜ | 9 |
| | | 114 | 87 | | 3 12 | | 13 0<br>6 sand.<br>13 6 | 5 28 | 1⅜ | 9 |
| | | 115 | 88 | | 3 12 | | 13 2<br>4 sand.<br>13 6 | 5 25 | 1⅜ | 9 |
| | | 116 | 89 | | 3 12 | | 13 0<br>6 sand.<br>13 6 | 5 23 | 1⅜ | 9 |
| | | 117 | 90 | | 3 12 | | 13 0<br>6 sand.<br>13 6 | 5 20 | 1⅜ | 9 |
| | | 118 | 91 | | 3 12 | | 12 15<br>7 sand.<br>13 6 | 5 20 | 1⅜ | 9 |
| | | 119 | 92 | | 3 12 | | 13 0<br>6 sand.<br>13 6 | 5 18 | 1⅜ | 9 |
| | | 120 | 93 | | 3 12 | Shell (lot 284), with band ½ inch wide and 0.625 inch from base. | 13 0<br>6 sand.<br>13 6 | 5 30 | 1⅜ | 9 |
| | | 121 | 94 | | 3 12 | | 12 14<br>8 sand.<br>13 6 | 5 30 | 1⅜ | 9 |

*Arsenal, at Sandy Hook, N. J., January 14, 1890*—Continued.

**with band 0.625 inch and 1.25 inches from base.]**

| Wind, strength and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|
| From right and rear, 23 miles an hour. | Gun mounted on Buffington steel field-carriage (light), No, 17. Wheels lashed to trail by rope. Cannon friction primers (experimental), with spiral serrated wire, March, 1890.<br>Fired at 3,000-yards target. Aimed at upper left edge of target. | Sighting shot. Struck 14 yards in front and 4 feet left of line. |
| | | Struck target 8 feet above and 1 foot left of center. |
| | Old spiral-spring brakes.<br>Fired at 3,000-yards target. Aimed at upper left corner of target. | Struck 275 yards beyond and 6 feet to left of target. |
| | | Struck 250 yards beyond and 6 feet to right of target. |
| | | First primer failed. Struck 252 yards beyond and 12 feet to right of target. |
| | | Struck 251 yards beyond and 5 feet to right of target. |
| | | Struck target 9 feet above and 11 feet left of center. |
| | | Struck 235 yards in rear and 4 feet to left of target. |
| | | Struck 112 yards beyond and 10 feet to left of target. |
| | | Struck 100 yards beyond and 6 feet to right of target. |
| | | Struck target 11 feet right and 4 feet above center. |
| | | Struck 112 yards beyond and 12 feet to right of target. |
| | Fired at 3,000-yards target | Struck 120 yards beyond target and 10 feet right. |
| | | Struck target 7 feet below and 7 feet right of center. |
| | | Struck 47 yards beyond and 8 feet to right of target. |
| | Gun sighted by Lieut. O. M. Lissak, O. D. Target observed by Corpl. Alward, ordnance detachment. Firing conducted by the proof officer. | |

*Record of firing with 3.2-inch B. L. rifle (steel), No. 26,*

[Object of firing, comparative test of 3.2-inch shell,

|  | No. of series. | No. of fire. | Powder. |  | Projectile. |  | Elevation. | Wind allowance (points). | Recoil. | Wind, strength and direction. |
|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  | Kind. | Weight. | Kind. | Weight. |  |  |  |  |
|  |  |  |  | *Lbs. Oz.* |  | *Lbs. Oz.* | ° ′ | *Right.* | *Feet.* |  |
| P. M. | 122 | 95 | Du Pont's I. K. H. Lot 16. Density, 1.725. Granulation, 2,524. | 3 12 | Shell (lot 284), with band ½ inch wide and 0.625 inch from base. | 12 15<br>7 sand.<br>13 6 | 5 28 | ½ | 9 | From right, 12 miles an hour. |
|  | 123 | 96 |  | 3 12 |  | 12 15<br>7 sand.<br>13 6 | 5 30 | *Left.*<br>½ | 9 |  |
|  | 124 | 97 |  | 3 12 |  | 13 1<br>5 sand.<br>13 6 | 5 32 | 1½ | 9 |  |
|  | 125 | 98 |  | 3 12 |  | 13 1<br>5 sand.<br>13 6 | 5 38 | 2 | 9 |  |
|  | 126 | 99 |  | 3 12 |  | 13 1<br>5 sand.<br>13 6 | 5 43 | 2 | 9 |  |
|  | 127 | 100 |  | 3 12 |  | 12 15<br>7 sand.<br>13 6 | 5 45 | 2 | 9 |  |
|  | 128 | 101 |  | 3 12 |  | 13 0<br>6 sand.<br>13 6 | 5 45 | 2 | 9 |  |
|  | 129 | 102 |  | 3 12 |  | 13 1<br>5 sand.<br>13 6 | 5 45 | 2 | 9 |  |
|  | 130 | 103 |  | 3 12 |  | 13 2<br>4 sand.<br>13 6 | 5 45 | 2 | 9 |  |
|  | 131 | 104 |  | 3 12 |  | 13 0<br>6 sand.<br>13 6 | 5 45 | 2 | 9 |  |
|  | 132 | 105 |  | 3 12 |  | 13 0<br>6 sand.<br>13 6 | 5 45 | 2 | 9 |  |
|  | 133 | 106 |  | 3 12 |  | 13 2<br>4 sand.<br>13 6 | 5 45 | 2 | 9 |  |

*Watervliet Arsenal, at Sandy Hook, N. J., January 15, 1891.*

**with band 0.625 inch and 1.25 inches from base.]**

| Distance from center of target. | | | | Distance from center of impact. | | | | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|---|---|---|---|---|---|
| Vertical | | Horizontal. | | Vertical. | | Horizontal. | | | |
| Above. | Below. | Right. | Left. | Above. | Below. | Right. | Left. | | |
| *Ft.* | *Ft.* | *Ft.* | *Ft.* | *Ft.* | *Ft.* | *Ft.* | *Ft.* | | |
| .... | .... | ...... | ...... | ...... | ...... | ...... | ...... | Gun mounted on Buffington steel field carriage (light), No. 17, with old spiral-spring brakes. Cannon friction primers (experimental), with spiral serrated wire, March, 1890. Fired at 3,000-yards target. Telescopic sight used. Aimed at upper left-hand corner of target. | Sighting shot. Struck 16 yards in front and 15 yards to right of target. |
| .... | .... | ...... | ...... | ...... | ...... | ...... | ...... | | Sighting shot. Struck 41 yards in front and 10 yards to right of target. |
| .... | .... | ...... | ...... | ...... | ...... | ...... | ...... | | Sighting shot. Struck 48 yards in front and 10 yards to right of target. |
| .... | .... | ...... | ...... | ...... | ...... | ...... | ...... | | Sighting shot. Struck 21 yards in front and ricochetted through target 10½ feet left and 5 feet above center. |
| .... | 15 | ½ | ...... | ...... | ...... | ...... | ...... | | Sighting shot. |
| .... | .... | ...... | 8 | ...... | .125 | 4.16 | ...... | | |
| .... | 1½ | ...... | 14 | ...... | 1.625 | ...... | 1.84 | | |
| .... | .... | ...... | ...... | ...... | ...... | ...... | ...... | | Miss. Struck 60 yards beyond and 12 yards to left of target. |
| .... | 2 | ...... | 9 | ...... | 2.125 | 3.16 | ...... | | |
| 3½ | .... | ...... | 16 | 3.375 | ...... | ...... | 3.84 | | |
| 1 | .... | ...... | 19 | .875 | ...... | ...... | 6.84 | | |
| .... | ½ | ...... | 7 | ...... | .375 | 5.16 | ...... | | |

*Record of firing with 3.2-inch B. L. rifle (steel), No. 26, Watervliet*

[Object of firing, comparative test of 3.2-inch shell.

| | No. of series. | No. of fire. | Powder. | | Projectile. | | Elevation. | Wind allowance (points). | Recoil. | Wind, strength and direction. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | | | |
| | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ′ | *Right.* | *Feet.* | |
| P. M. | 134 | 107 | Du Pont's I. K. H. Lot 16. Density, 1.725. Granulation, 2.524. | 3 12 | Shell (lot 284), with band ¾ inch wide and 0.625 inch from base. | 13 4<br>2 sand.<br>13 6 | 5 45 | 2 | 9 | From right, 12 miles an hour. |
| | 135 | 108 | | 3 12 | | 13 2<br>4 sand.<br>13 6 | 5 45 | 2 | 9 | |
| | 136 | 109 | | 3 12 | | 13 0<br>6 sand.<br>13 6 | 5 45 | 2 | 9 | |
| | 137 | 110 | Du Pont's I. K. H. Lot 16. Density, 1.725. Granulation, 2,525. | 3 12 | Shell (lot 297), with band ¾ inch wide and 1.25 inches from base. | 12 15<br>7 sand.<br>13 6 | 5 25 | 1¾ | 9 | From right, 9 miles an hour. |
| | 138 | 111 | | 3 12 | | 13 1<br>5 sand.<br>13 6 | 5 25 | 1¾ | 9 | |
| | 139 | 112 | | 3 12 | | 13 2<br>4 sand.<br>13 6 | 5 25 | 1¾ | 9 | |
| | 140 | 113 | | 3 12 | | 12 14<br>8 sand.<br>13 6 | 5 25 | 1¾ | 9 | |
| | 141 | 114 | | 3 12 | | 13 0<br>6 sand.<br>13 6 | 5 25 | 1¾ | 9 | |
| | 142 | 115 | | 3 12 | | 12 15<br>7 sand.<br>13 6 | 5 25 | 1¾ | 9 | |

***Arsenal, at Sandy Hook, N. J., January 15, 1891*—Continued.**

**with band 0.625 inch and 1.25 inches from base.]**

| Distance from center of target. | | | | Distance from center of impact. | | | | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|---|---|---|---|---|---|
| Vertical | | Horizontal. | | Vertical. | | Horizontal. | | | |
| Above. | Below. | Right. | Left. | Above. | Below. | Right. | Left. | | |
| *Ft.* | *Ft.* | *Ft.* | *Ft.* | *Ft.* | *Ft.* | *Ft.* | *Ft.* | | |
| .... | .... | ...... | ...... | ...... | ...... | ...... | ...... | Fired at 3,000-yards target. | Miss. Struck 50 yards in rear and 5 yards to left of target. |
| .... | .... | ...... | ...... | ...... | ...... | ...... | ...... | | Miss. Struck 78 yards in rear and in line with left edge of target. |
| .... | .... | ...... | ...... | ...... | ...... | ...... | ...... | | Miss. Struck 88 yards in rear and in line with left edge of target. |
| Gun sighted by Lieut O. M. Lissak, O. D. Target observed by Corpl. Maloney, ordnance detachment. | | | | | | | | | Center of impact: *Feet.*<br>Above ........ 0.125<br>Left ........ 12.16<br>Mean vertical deviation from center of impact ........ 1.416<br>Mean horizontal deviation from center of impact ........ 4.173<br>Mean deviation from center of impact ........ 4.406 |
| 7½ | .... | ...... | 7 | 12.2 | ...... | 2.35 | ...... | Gun mounted on Buffington steel field carriage (light), No. 17, with old spiral-spring brakes. Cannon friction primers (experimental), with spiral serrated wire, March, 1890. Fired at 3,000-yards target. Telescopic sight used. Aimed at upper left-hand corner of target. | |
| .... | 6½ | ...... | 2½ | ...... | 1.8 | 6.85 | ...... | | |
| .... | .... | ...... | ...... | ...... | ...... | ...... | ...... | | |
| .... | 14 | ...... | 16 | ...... | 9.3 | ...... | 6.65 | | Struck 6 feet in front and passed under center of target. |
| 1½ | .... | ...... | 11¼ | 6.2 | ...... | ...... | 1.90 | | |
| .... | 12 | ...... | 10 | ...... | 7.3 | ...... | .65 | | |
| Gun sighted by Lieut. O. M. Lissak, O. D. Target observed by Corpl. Maloney, ordnance detachment.<br>Firing conducted by the proof officer. | | | | | | | | | Wind dropped from 12 miles an hour at 1 o'clock to 9 miles an hour at 4 o'clock.<br>Center of impact: *Feet.*<br>Below ........ 4.7<br>Left ........ 9.35<br>Mean vertical deviation from center of impact ........ 7.36<br>Mean horizontal deviation from center of impact ........ 3.68<br>Mean deviation from center of impact ........ 8.22 |

# APPENDIX 35.

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## *REPORT ON TEST OF EXPERIMENTAL CARRIAGE FOR 5-INCH B. L. SIEGE GUN, STEEL.*

(One plate.)

### PRELIMINARY TEST OF 5-INCH SIEGE-GUN CARRIAGE.

U. S. ORDNANCE PROVING GROUND,
*Sandy Hook, N. J., March 31, 1891.*

The CHIEF OF ORDNANCE, U. S. ARMY,
*Washington, D. C.:*

SIR: In accordance with your instructions, I submitted on December 4, 1890, a programme for the preliminary test of the 5-inch siege-gun carriage with a hydraulic cylinder, as follows:

To gradually increase the powder charge from 10 pounds to 14 pounds of O. I. N. powder and then fire—

Five rounds at 5 degrees.
Five rounds at 10 degrees.
Ten rounds at 15 degrees.
Five rounds at 20 degrees.
Five rounds at 25 degrees.
Five rounds at 30 degrees.
Five rounds at 35 degrees.

The gun was the 5-inch B. L. rifle, steel, with a counterpoise of cast iron added in front of the trunnions to change the original preponderance of about 400 pounds to 0 pound. The powder used was black prismatic powder, furnished by Du Pont & Co., of the O. I. N. type, 14 pounds of which on previous trials had given a mean pressure of 35,072 pounds per square inch. The projectiles were shell, without either fuse or bursting charge, and weighed 45 pounds.

The carriage was similar to the one originally made for this gun, which is described and illustrated in the Report of the Chief of Ordnance for 1887, p. 169. It was, however, furnished with a hydraulic buffer.

The hydraulic buffer is a steel cylinder, with a bore 5 inches in diameter and 42 inches in length. The bore contains a throttling bar of steel fastened to the upper part of the cylinder by five tap bolts. The cylinder contains a piston with a rectangular slot in its upper part. The throttling bar is of equal width but of varying depth throughout, as its lower surface is curved. The slot in the piston is slightly wider than the bar, and is deeper than the greatest depth of the bar. The curve on the bar and the depth of the slot are so arranged as to give with a suitable medium an equal resistance to the movement of the piston throughout the whole extent of its path, which in this case was 37 inches.

Originally a pair of Belleville springs was inserted at the rear of the bore, but they were found to be hurtful, rather than an aid, to the system. The piston was connected by means of a reverse cone and slight shrinkage to a steel rod which passed through a stuffing box at the rear of the cylinder, and terminated in a screw thread to which a stout eye was attached. This eye was connected by a pin to a lug forming part of a plate bolted to the bottom transom plate of the flask. Collars bearing trunnions were fitted to the front and rear of the cylinder, and side straps affixed to the trunnions projected well forward and terminated in eyes. Journals formed on each end of a crosshead passed through the strap eyes. The straps were secured to the trunnions of the cylinder collars and to the journals of the crosshead by spring pins. A stout bolt passed through a hole in the crosshead and was inserted in the hole of a cast-iron pintle block, being held in place by a nut screwed to its lower end. The block was placed on a platform and held in position by eight bolts ⅞ inch in diameter. During the firing the cylinder was filled with neutral oil.

The platform was temporary in its nature, and is therefore not described.

The experiments began December 15, 1890, when 10-pound charges were used. At the first round the recoil was 24¼ inches; at the second it was checked at 11⅝ inches. Examination showed that the piston was jammed in the cylinder by small chips of metal, and that the piston and cylinder were badly scored. A rivet in the flask, a tap bolt in the box for the right journal of the elevating crosshead, and a bolt in the right axle plate were broken. The cylinder and piston were put in good order and firing was resumed on the 19th and continued on the 24th of December. At the eighth round of the series a charge of 13 pounds was fired, and the recoil which, with 12 pounds, had been from 31½ to 32⅜ inches was sharply checked at 24¾ inches. The front of the carriage rose high and came down with violence, breaking nine rivets in the left side of the axle plate. The cylinder was again examined, and it was found scored again, while the piston was started off the rod.

Repairs were made and the gun was fired the ninth round of the series on January 7. The breechblock was injured, and after this round had to be sent to Watervliet Arsenal for repair.

After its return, in firing the twelfth round of the series, the piston head pulled off.

The following changes were then made:

(1) As the steel pieces found in the cylinder which abraded the piston were supposed to be scraped off by the Belleville springs, they were removed.

(2) The piston was expanded by heat, replaced on the end of the rod and secured to it by three screws parallel to the axis of the cylinder, and halved into the rod and the piston.

(3) All rivets broken or started were removed and replaced by new wrought-iron rivets.

These changes having been made and preliminary firing having been completed, firing in accordance with the programme commenced March 6, with a 14-pound charge under 0 degree elevation.

Rivets broke from time to time, some of them showing hammer cracks, and where they broke in the vicinity of parts subjected to the greatest strain they were replaced by new iron rivets. In no case did the new iron rivets which replaced them break. One bolt broke off in the left cheek of the carriage and showed a bad flaw, but firing was continued without replacing it.

The firing was continued on March 19, when twenty-five rounds were fired as follows:

Five rounds at 5 degrees.
Five rounds at 10 degrees.
Ten rounds at 15 degrees.
Five rounds at 20 degrees.

There was nothing particularly worthy of note except that the cap on the journal box, which supports the heavy crosshead of the elevating apparatus, had a tap bolt which connects it with the carriage broken. This same bolt was broken several times, showing that the construction was very faulty and must be modified. When the bolt breaks the gears work stiffly and repairs have to be made.

On March 24 five rounds were fired under 25 degrees and one under 30 degrees. At this round, the forty-ninth of the series, a steel pallet inserted in the safety notch of the carrier ring broke and had to be replaced.

On March 26 four rounds were fired under 30 degrees and five rounds under 35 degrees.

This completed the preliminary trial.

## REMARKS.

The following breakages of rivets and bolts occurred:

| Round No. | Rivets. | Location. | Remarks. |
|---|---|---|---|
| 1 | 2 | Left side flask, through upper transom plate.. | Near elevating apparatus. |
| 2 | 1 | Right side flask, through upper transom plate. | Do. |
| 4 | 1 | Left side flank, through upper transom plate.. | Do. |
| 8 | 9 | Axle plate, left side.......................... | Recoil sharply checked. |
| 17 | 2 | ......do........................................ | Started before. |
| 44 | 1 | Right side flask, through upper transom plate. | Near trail; not replaced. |
| 46 | 2 | Left side flask, through upper transom plate.. | Do. |
|  | 18 | Broken; fifteen replaced with wrought-iron rivets which did not break. |  |
|  | Bolts. |  |  |
| 1 | 1 | Tap bolt in journal box of crosshead ......... | Replaced. |
| 2 | 1 | Right side, through stiffener and axle plate... | Do. |
| 18 | 1 | Bolt and nut, left side, through cheek and stiffener. | Not replaced. |
| 44 | 1 | Tap bolt in journal box of crosshead .......... | Replaced. |
| 47 | 1 | On left side, through cheek and stiffener...... | Burnt in forging; not replaced. |
| 50 | 1 | Tap bolt in journal box of crosshead.......... | Not replaced, because firing was nearly completed. |
|  | 6 | Broken; tap bolts of journal boxes three times. |  |

After firing under 35 degrees the axle was found to be badly sprung downward. Such springing was not previously observed. The carriage is, however, still serviceable, although if any more firing is to be conducted under very high angles the axle will probably become disabled.

The object of this preliminary trial was to ascertain as soon as possible if the carriage would immediately break down with heavy charges under high angles, and proved that it would not.

A second programme was then arranged as follows:

15 rounds at 5 degrees elevation.
25 rounds at 10 degrees elevation.
30 rounds at 15 degrees elevation.
30 rounds at 20 degrees elevation.
20 rounds at 25 degrees elevation.
10 rounds at 30 degrees elevation. In all 130 rounds.

No repairs were made to the carriage before commencing this series except those indicated already in the report. During this series four rivets were broken in the upper transom plate. At the sixty-ninth round the two separable journal boxes for the crosshead of the elevating apparatus were each replaced by single castings held in place by five bolts and nuts instead of by three bolts and nuts and two tap bolts. The tap bolts broke several times, while when bolts and nuts were substituted for them breakage ceased.

At the eighty-third round, owing to the fact that the carriage was fired with the axis of trail sharply inclined to that of the cylinder, the piston rod broke at the origin of the screw thread which connected the eye to the rod, the eye itself being assembled to the trail by a pin. As no steel rod was on hand a wrought iron one was substituted, which broke down speedily, and at the ninety-third round a new steel rod was substituted having a plus instead of a minus thread. This rod was satisfactory.

The axle, which had been sprung during the firing under 35 degrees, was not straightened, but during the firing of the one hundred and thirty rounds of the last series did not appear to undergo any change.

As a result of the trial it may be stated that where broken rivets were replaced by new ones carefully set the new rivets endured in all cases, but it is evident that there is not a sufficient margin of safety, as imperfectly driven rivets may sometimes by accident be inserted. All rivets, then, in the upper transom plate should be increased in diameter from one-half inch to five-eighths inch.

The other changes which were made during the firing, viz, the substitution of solid for separable journal boxes and the use of a plus instead of a minus thread at the end of the piston rod, made during the progress of the experiment, proved satisfactory. It will be necessary to change the curve of the throttling bar to suit a mixture of 4 parts of water to 1 of glycerine, as this mixture should be used in service. It is nonfreezing, and generally easily obtained, while a suitable neutral oil of a fixed specific gravity might not always be procurable.

Firing under an angle of 35 degrees will so seldom be resorted to that it hardly seems necessary to provide for it, but, if it should be considered essential, then the axle will have to be increased to 4 inches in diameter, and made hollow to keep the weight down to that of the present one while increasing the strength and stiffness.

The experiments further indicate that a portion of the metal of the flasks between the front and rear transom plates may be removed with advantage as being superfluous, but this can first be done with the present carriage, and tested in current firings for the proof of guns and projectiles.

In conclusion it may be stated that with the changes indicated the carriage will be suitable for issue to the Army for such trials incident to the service as can not be given it at the proving ground.

The records of the firings are furnished herewith.

Respectfully submitted.

CHARLES SHALER,
*Captain, Ord. Dept., U. S. Army.*

(2058-'91.)

*Record of firing with 5-inch B. L. siege rifle (steel), No. 1, Watertown*

[Object of firing, trial of

| Date. | | No. of series. | No. of fire. | Powder. | | Projectile. | | Travel of shot in bore. | Elevation. | Pressure, per square inch of bore. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1890. | | | | | *Lbs. Oz.* | | *Lbs. Oz.* | *Inches.* | ° ′ | *Pounds.* |
| Dec. 12 | P. M. | 1 | 1,001 | Du Pont's black prismatic, O. I. N.; density, 1.800; 12 prisms in cross section. | *10 0 | Shell rebanded. | §44 8 | ........ | 0 00 | Less than 24,000. |
| Dec. 15 | | 2 | 1,002 | | *10 0 | | §44 8 | 117.29 | 0 00 | No.2, 19,780<br>No.1, 19,860 |
| Dec. 15 | | 3 | 1,003 | | *10 0 | | 44 8 | 117.29 | 0 00 | ............. |
| Dec. 19 | A. M. | 4 | 1,004 | | *10 0 | | 44 11<br>5 sand.<br>45 0 | 118.49 | 0 00 | ............. |
| | | 5 | 1,005 | | †12 0 | | §44 10 | 119.49 | 0 00 | No. 1, 26,940 |
| Dec. 24 | | 6 | 1,006 | | †12 0 | | §44 8 | ........ | 0 00 | ............. |
| | | 7 | 1,007 | | †12 0 | | §44 8 | ........ | 0 00 | ............. |
| | | 8 | 1,008 | | ‡13 0 | | §44 8 | ........ | 0 00 | No. 1, 30,060 |

* 108 prisms. † 128 prisms. ‡ 140 prisms. § Natural weight.

*Arsenal, at Sandy Hook, N. J., from December 12 to December 24, 1890.*

5-inch siege-gun carriage.]

| Recoil. | Wind, strength and direction. | | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|---|
| *Inches.* | | | | |
| 25⅝ | From right and rear, 34 miles an hour. | | Gun mounted on new 5-inch steel siege carriage with hydraulic buffer. Received from Watervliet Arsenal December 8, 1890.<br>2¼ gallons of oil in cylinder.<br>Obturating friction primers.<br>Strips of 2-inch plank nailed on platform outside of and parallel to wheels.<br>Fired from platform on fort wall. Fired into sand butt, section 7.<br>Hydraulic cylinder leaked slightly.<br>Pressure taken by Lieut. W. W. Gibson, O. D.<br>Firing conducted by the proof officer. | Heads of two rivets in left side of flask of carriage broken off.<br>Copper cylinders of 24,000 pounds initial compression and tables of 1887. |
| 24¼ | From front, 13 miles an hour. | | Gun mounted on new 5-inch steel siege carriage with hydraulic buffer. Received from Watervliet Arsenal December 8, 1890.<br>Obturating friction primers.<br>Fired from platform on fort wall. Fired into sand butt, section 7.<br>Before round 1,002 screw plug of filling hole of cylinder replaced by headed bolt and copper washer.<br>Fired into sand butt, section 7. | First rivet in flask right side broken off.<br>Upper top bolt for assembling shaft broken off right side.<br>One bolt on right side of axle plate broken.<br>Carriage run into battery with difficulty.<br>Pinch bars used under wheels.<br>Counter recoil 20¼ inches.<br>Copper cylinders of 18,000 pounds initial compression and tables of 1887. |
| 11⅝ | | | Pressures taken by Lieut. W. W. Gibson, O. D.<br>Firing conducted by the proof officer. | Recoil sharply checked at 11⅝ inches. Cylinder removed for examination. Piston head found jammed in cylinder by small chips of metal left in cylinder after boring. Piston head and cylinder badly scored and burred. Burrs removed. |
| | | Counter recoil. | | |
| | | *Inches.* | | |
| 24½ | From right and rear, 25 miles an hour. | 6½ | Round 1,004 fired into sand butt, section 7.<br>Broken rivets and bolt replaced before this firing.<br>Fired to sea.<br>Obturating friction primers. | New keys put in cylinder frame. Second rivet on flask, left side, broken. |
| 31½ | From front, 24 miles an hour. | 10 | | Gun lashed to elevating apparatus with rope. Copper cylinder of 24,000 pounds initial compression and tables of 1887. |
| 32⅝ | | 12 | | Carriage run into battery with slight difficulty, pinch bars used under wheels. |
| 31¼ | | 8 | | Nine rivets broken off axle plate, left side. |
| 24¾ | | 8 | | After this round cylinder removed and examined. Piston head and cylinder found scored and burred; also piston head started off rod $\frac{3}{16}$ of an inch.<br>Copper cylinder of 28,000 pounds initial compression and tables of 1887. |
| | | | Pressures taken by Lieut. O. M. Lissak, O. D.<br>Firing conducted by the proof officer. | |

*Record of firing with 5-inch B. L. siege rifle (steel), No. 1, Watertow*

[Object of firing, to test

| Date. | | No. of series. | No. of fire. | Powder. | | Projectile. | | Travel of shot in bore. | Elevation. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Kind. | Weight. | Kind. | Weight. | | |
| 1891. | | | | | *Lbs. Oz.* | | *Lbs. Oz.* | *Inches.* | ° ′ |
| Jan. 7 | A. M........ | 9 | 1,009 | Du Pont's black prismatic, O. I. N.; density, 1.800; 12 prisms in cross section. | 12 0<br>130 prisms. | Shell rebanded. | 41 8<br>3 8 sand<br>45 0 | ........ | ........ |
| Mar. 4 | P. M...... | 10 | 1,010 | | 10 0<br>108 prisms. | | 42 0<br>3 0 sand.<br>45 0 | ........ | 0 00 |
| | | 11 | 1,011 | | 10 0<br>108 prisms. | | 41 8<br>3 8 sand.<br>45 0 | ........ | 0 00 |
| | | 12 | 1,012 | | 13 0<br>140 prisms. | | 44 8<br>8 sand.<br>45 0 | ........ | 0 00 |
| Mar. 6 | P. M...... | 13 | 1,013 | | 13 0<br>140 prisms. | | 41 3<br>3 13 sand.<br>45 0 | 119.49 | 0 00 |
| | | 14 | 1,014 | | 14 0<br>151 prisms. | | 41 12<br>3 4 sand.<br>45 0 | 119.49 | 0 00 |
| | | 15 | 1,015 | | 14 0<br>151 prisms. | | 41 0<br>4 0 sand.<br>45 0 | ........ | 0 00 |
| | | 16 | 1,016 | | 14 0<br>151 prisms. | | 42 0<br>3 0 sand.<br>45 0 | ........ | 0 00 |
| | | 17 | 1,017 | | 14 0<br>151 prisms. | | 45 0 natural weight. | ........ | 0 00 |
| | | 18 | 1,018 | | 14 0<br>151 prisms. | | 41 6<br>3 10 sand.<br>45 0 | ........ | 0 00 |

***Arsenal, at Sandy Hook, N. J., from January 7 to March 6, 1891.***

**of siege-gun carriage.]**

| Pressure per square inch of bore. | Recoil. | Wind, strength and direction. | Counter recoil. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|---|---|
| *Pounds.* | *Inch.* | | *Inch.* | | |
| ............... | 33½ | From left and rear, 18 miles an hour. | 9 | Gun mounted on new 5-inch steel siege carriage, with hydraulic buffers. Received from Watervleit Arsenal December 8, 1890.<br>37½ inches recoil allowed.<br>Fired to sea.<br>Obturating friction primers.<br>Since last firing burrs removed from piston head and cylinder, and all broken rivets on axle plate replaced by new ones.<br>Firing conducted by the proof officer. | Mallet used in opening breechblock. Breechblock turned slightly by discharge until cam of lever handle struck left edge of notch in carrier ring. Lever handle partially raised. Cam and edge of notch in carrier ring badly upset. Plate on rear of breech block, bearing lugs for lever handle, cracked at base of right lug opposite screw hole. Top of plate faced away from block about one-sixteenth of an inch. Block and carrier ring removed. |
| ............... | 29 | From right and rear, 18 miles an hour. | ...... | Gun mounted on new 5-inch steel siege carriage, with hydraulic buffer. Received from Watervleit Arsenal December 8, 1890.<br>2½ gallons of oil in<br>Since last firing the cylinder was removed; piston rod ground down and replaced; new face plate placed on breechblock; slot in block enlarged, so as to prevent pin in carrier ring from bearing against side of slot when block was closed.<br>Obturating friction primers.<br>Firing conducted by Lieut. W. W. Gibson, O. D., assistant proof officer. | Cylinder leaked slightly after this round. |
| ............... | 29½ | | ...... | | Piston head pulled off rod. |
| ............... | | | | | |
| ............... | 34 | ........ | 13 | Gun mounted on new 5-inch steel siege carriage, with hydraulic buffer. Received from Watervleit Arsenal December 8, 1890.<br>Since last firing the cylinder was removed, piston head shrunk on piston rod, and end of rod upset. Three spline screws fitted in piston head and rod. Stuffing box smoothed.<br>Full recoil is 37½ inches.<br>Copper cylinders of 32,000 pounds initial compression and tables of 1890.<br>Fired down the beach.<br>Full recoil is 37½ inches.<br>Obturating friction primers.<br>Firing conducted by Lieut. O. M. Lissak, O. D., assistant proof officer. | |
| No. 2, 34,000 | 20⅞ | ........ | 14 | | Cast-iron sleeve moved forward on tube three-sixteenths of an inch. |
| ............... | 23¼ | ........ | 13⅛ | | Cast-iron sleeve went back to place. |
| No. 2, 34,600 | 20¼ | From right and front 12 miles an hour. | 13 | | |
| ............... | 20⅝ | | 13 | | Two rivets broken off left axle plate. |
| No. 2, 34,200 | 22¼ | | 13 | | One bolt broken off left cheek of carriage. One nut broken off left cheek of carriage. Cast-iron sleeve slipped forward 8¼ inches and returned to place. |

*Record of firing with 5-inch B. L. siege rifle (steel), No. 1.*

[Object of firing, test

| Date. | | No. of series. | No. of fire. | Powder. Kind. | Powder. Weight. | Projectile. Kind. | Projectile. Weight. | Travel of shot in bore. | Elevation. |
|---|---|---|---|---|---|---|---|---|---|
| 1891. | | | | | *Lbs. Oz.* | | *Lbs. Oz.* | *Inches.* | ° ' |
| Mar. 19 | A. M...... | 19 | 1,019 | Du Pont's black prismatic, O. I. N.; density, 1.800; 12 prisms in each cartridge; 12 prisms in cross section. | 14 0<br>151 prisms. | Shell rebanded. | 42 0<br>3 0 sand.<br>45 0 | ........ | 5 00 |
| | | 20 | 1,020 | | 14 0<br>151 prisms. | | 42 0<br>3 0 sand.<br>45 0 | ........ | 5 00 |
| | | 21 | 1,021 | | 14 0<br>151 prisms. | | 41 6<br>3 10 sand.<br>45 0 | ........ | 5 00 |
| | | 22 | 1,022 | | 14 0<br>151 prisms. | | 42 0<br>3 0 sand.<br>45 0 | ........ | 5 00 |
| | | 23 | 1,023 | | 14 0 | | 42 0<br>3 0 sand.<br>45 0 | ........ | 10 00 |
| | | 24 | 1,024 | | 14 0 | | 43 0<br>2 0 sand.<br>45 0 | ........ | 10 00 |
| | | 25 | 1,025 | | 14 0 | | 43 8<br>1 8 sand.<br>45 0 | ........ | 10 00 |
| | | 26 | 1,026 | | 14 0 | | 42 0<br>3 0 sand.<br>45 0 | ........ | 10 00 |
| | | 27 | 1,027 | | 14 0 | | 41 0<br>4 0 sand.<br>45 0 | ........ | 10 00 |
| | | 28 | 1,028 | | 14 0 | | 41 0<br>4 0 sand.<br>45 0 | ........ | 10 00 |
| | | 29 | 1,029 | | 14 0 | | 41 0<br>4 0 sand.<br>45 0 | ........ | 15 00 |
| | | 30 | 1,030 | | 14 0 | | 41 6<br>3 10 sand.<br>45 0 | ........ | 15 00 |
| | | 31 | 1,031 | | 14 0 | | 42 0<br>3 0 sand.<br>45 0 | ........ | 15 00 |
| | | 32 | 1,032 | | 14 0 | | 42 0<br>3 0 sand.<br>45 0 | ........ | 15 00 |

*Watertown Arsenal, at Sandy Hook, N. J., March 19, 1891.*

of siege-gun carriage.]

| Pressure per square inch of bore. | Recoil. | Wind, strength and direction. | Counter recoil. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|---|---|
| *Pounds.* | *Inch.* | | *Inch.* | | |
| No. 2, 33, 960 | 36½ | From left, 18 miles an hour. | 11 | Gun mounted on new 5-inch siege carriage, with hydraulic buffers. Received from Watervleit Arsenal December 8, 1891.<br>Rope fastened around breech and elevating device.<br>Fired to sea. Aimed to left of 3,000-yards target.<br>Iron sleeve fastened to gun with three set screws.<br>Cylinder leaked slightly after round 1,021. | Copper cylinders of 32,000 pounds initial compression and tables of 1890. |
| ............... | 37 | | 12½ | | |
| ............... | 36⅛ | | 12 | | |
| ............... | 36¾ | | 12½ | | Breechblock opened with slight difficulty. Front cup wiped off. Stuffing box tightened. |
| ............... | 36¾ | | 10 | Obturating friction primers.<br>Copper cylinders of 32,000 pounds initial compression and tables of 1890.<br>Fired to sea. Rounds 1,023 to 1,025 aimed to the left of 3,000-yards target; rounds 1,026 to 1,032, inclusive, aimed to left of 1-mile target.<br>Guiding fork on top of elevating screw bent. | |
| No. 2, 34, 700 | 35 | | 5 | | |
| ............... | 36¾ | | 8 | | |
| ............... | 36 | | 5½ | | Front cup wiped off. |
| ............... | 35 | | 6 | | Rope removed from breech and elevating device. |
| ............... | 36 | | 7 | | |
| No. 2, 34, 800 | 32½ | | ...... | | Iron plate placed under trail of carriage. |
| ............... | 32¾ | | ...... | | |
| ............... | 32¾ | | ...... | | Muzzle struck platform. |
| ............... | 32¾ | | ...... | | |

*Record of firing with 5-inch B. L. siege rifle (steel), No. 1, Watertown*

[Object of firing, test

| Date. | | No. of series. | No. of fire. | Powder. | | Projectile. | | Travel of shot in bore. | Elevation. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Kind. | Weight. | Kind. | Weight. | | |
| 1891. | | | | | *Lbs. Oz.* | | *Lbs. Oz.* | *Inches.* | ° ' |
| Mar. 19 | A. M...... | 33 | 1,033 | Du Pont's black prismatic, O. I. N.; density, 1.800; 151 prisms in each cartridge; 12 prisms in cross section. | 14 0 | Shell rebanded | 41 8<br>4 8 sand.<br>45 0 | ........ | 15 00 |
| | | 34 | 1,034 | | 14 0 | | 42 0<br>3 0 sand.<br>45 0 | ........ | 15 00 |
| | | 35 | 1,035 | | 14 0 | | 40 8<br>4 8 sand.<br>45 0 | ........ | 15 00 |
| | | 36 | 1,036 | | 14 0 | | 41 8<br>3 8 sand.<br>45 0 | ........ | 15 00 |
| | | 37 | 1,037 | | 14 0 | | 42 0<br>3 0 sand.<br>45 0 | ........ | 15 00 |
| | | 38 | 1,038 | | 14 0 | | 42 0<br>3 0 sand.<br>45 0 | ........ | 15 00 |
| Mar. 19 | P. M...... | 39 | 1,039 | | 14 0 | | 44 3<br>13 sand.<br>45 0 | ........ | 20 00 |
| | | 40 | 1,040 | | 14 0 | | 42 0<br>3 0 sand.<br>45 0 | ........ | 20 00 |
| | | 41 | 1,041 | | 14 0 | | 42 0<br>3 0 sand.<br>45 0 | ........ | 20 00 |
| | | 42 | 1,042 | | 14 0 | | 41 10<br>3 6 sand.<br>45 0 | ........ | 20 00 |
| | | 43 | 1,043 | | 14 0 | | 41 10<br>3 6 sand.<br>45 0 | ........ | 20 00 |
| Mar. 24 | A. M...... | 44 | 1,044 | | 14 0 | | 42 0<br>3 0 sand.<br>45 0 | ........ | 25 00 |
| | | 45 | 1,045 | | 14 0 | | 42 0<br>3 0 sand.<br>45 0 | ........ | 25 00 |
| | | 46 | 1,046 | | 14 0 | | 42 0<br>3 0 sand.<br>45 0 | ........ | 25 00 |
| | | 47 | 1,047 | | 14 0 | | 41 0<br>4 0 sand.<br>45 0 | ........ | 25 00 |

*Arsenal, at Sandy Hook, N. J., from March 19 to March 24, 1891.*

of siege-gun carriage.]

| Pressure per square inch of bore. | Recoil. | Wind, strength and direction. | Counter recoil. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|---|---|
| *Pounds.* | *Inch.* | | *Inch.* | | |
| ........ | 32½ | From left, 18 miles an hour. | ...... | Gun mounted on new 5-inch siege carriage, with hydraulic buffer. Received from Watervliet Arsenal December 8, 1891.<br>Obturating friction primers. | |
| ........ | 32¾ | | ...... | | One tap bolt in elevating gear broken. |
| ........ | 33¼ | | ...... | | One rivet (undercut) in trail, right side, broken. |
| ........ | 32¾ | | ...... | | One rivet in trail, right side, broken. |
| ........ | 32¾ | | ...... | | One rivet in trail, right side, broken. |
| ........ | 32¼ | | ...... | Fired to sea. Aimed to the left of 1-mile target. | |
| No. 2, 34,300 | 33¼ | | ...... | | Copper cylinder of 32,000 pounds initial compression, and tables of 1890. |
| ........ | 33 | | ...... | Shaft bearing pinion badly bent. | |
| ........ | 32¼ | | ...... | | |
| ........ | 33 | | ...... | | Elevating apparatus worked stiffly. |
| ........ | 32¾ | | ...... | Firing conducted by Lieut. C. B. Wheeler, O. D., assistant proof officer. | |
| No. 3, 34,800 | 32 | From left and rear, 15 miles an hour. | ...... | Gun mounted on new 5-inch steel siege carriage, with hydraulic buffer. Received from Watervliet Arsenal December 8, 1891.<br>Obturating friction primers.<br>Copper cylinders of 32,000 pounds initial compression and tables of 1890.<br>Fired to sea. Aimed between 1-mile and 3,000-yards target. | One rivet broken off trail, right side. |
| ........ | 32 | | ...... | | Tap bolt of elevating gear broken. |
| ........ | 33 | | ...... | | Two rivets broken off trail, left side. |
| ........ | 31 | | ...... | | |

*Record of firing with 5-inch B. L. siege rifle (steel), No. 1, Watertown*

[Object of firing. test

| Date. | | No. of series. | No. of fire. | Powder. | | Projectile. | | Travel of shot in bore. | Elevation. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Kind. | Weight. | Kind. | Weight. | | |
| 1891. | | | | | *Lbs. Oz.* | | *Lbs. Oz.* | *Inches.* | ° ′ |
| Mar. 24 | A. M...... | 48 | 1,048 | Du Pont's black prismatic, O. I. N.; density, 1.800; 151 prisms in each cartridge; 12 prisms in cross section. | 14 0 | Shell rebanded. | 41 8<br>3 8 sand.<br>45 0 | ........ | 25 00 |
| | | 49 | 1,049 | | 14 0 | | 41 0<br>4 0 sand.<br>45 0 | ........ | 30 00 |
| Mar. 26 | ............ | 50 | 1,050 | | 14 0 | | 44 0<br>1 0 sand.<br>45 0 | ........ | 30 00 |
| | | 51 | 1,051 | | 14 0 | | 43 0<br>2 0 sand.<br>45 0 | ........ | 30 00 |
| | | 52 | 1,052 | | 14 0 | | 45 0 natural weight. | ....... | 30 00 |
| | | 53 | 1,053 | | 14 0 | | 42 0<br>3 0 sand.<br>45 0 | ........ | 30 00 |
| | | 54 | 1,054 | | 14 0 | | 42 8<br>2 8 sand.<br>45 0 | ........ | 35 00 |
| | | 55 | 1,055 | | 14 0 | | 43 0<br>2 0 sand.<br>45 0 | ........ | 35 00 |
| | | 56 | 1,056 | | 14 0 | | 43 0<br>2 0 sand.<br>45 0 | ........ | 35 00 |
| | | 57 | 1,057 | | 14 0 | | 42 0<br>3 0 sand.<br>45 0 | ........ | 35 00 |
| | | 58 | 1,058 | | 14 0 | | 42 0<br>3 0 sand.<br>45 0 | ........ | 35 00 |

*Arsenal, at Sandy Hook, N. J., from March 24 to March 26, 1891.*

**of siege-gun carriage.]**

| Pressure per square inch of bore. | Recoil. | Wind, strength and direction. | Counter recoil. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|---|---|
| *Pounds.* | *Inch.* | | *Inch.* | Gun mounted on new 5-inch steel siege carriage, with hydraulic buffer. Received from Watervliet Arsenal, December 8, 1891. | |
| .............. | 33 | From left and rear, 15 miles an hour. | ...... | Since last firing shaft bearing pinion straightened and burrs removed.<br>Broken bolts and rivets replaced by new ones. | One bolt broken off left side of carriage. |
| No. 3, 34, 770 | 28⅜ | | ...... | | Elevating gear worked stiffly. Corner of steel piece let into carrier ring on left side of recess broken off for a length of ¼ inch. |
| | | | | Firing conducted by Lieut. W. W. Gibson, O. D., assistant proof officer. | |
| .............. | 30⅜ | ........ | ...... | Obturating friction primers. Fired to sea.<br>Guiding fork on top of elevating screw straightened before this firing.<br>Copper cylinder of 32,000 pounds initial compression and tables of 1890. | Iron plate used under trail was removed. First primer failed. |
| .............. | 32¼ | ........ | ...... | | Tap bolt of elevating gear broken. |
| .............. | 31⅜ | ........ | ...... | | Elevating screw became jammed. Could be turned with difficulty. |
| .............. | 32⅛ | ........ | ...... | | |
| No. 3, 35, 290 | 31¼ | ........ | ...... | | Breechblock opened with difficulty. |
| .............. | 31 | ........ | ...... | | Front cup wiped off and oiled. Breechblock opened easily. |
| .............. | 30¼ | ........ | ...... | | |
| .............. | 30¼ | ........ | ...... | | |
| .............. | 30⅞ | ........ | ...... | | |
| | | | | Firing conducted by Lieut. C. B. Wheeler, O. D., assistant proof officer. | |

*Record of firing with 5-inch B. L. siege rifle (steel), No. 1, Watertown*

[Object of firing, test

| Date. | | No. of fire with carriage. | No. of fire. | Powder. | | Projectile. | | Elevation. | Pressure per square inch of bore. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Kind. | Weight. | Kind. | Weight. | | |
| 1891. | | | | | *Lbs. Oz* | | *Lbs. Oz.* | ° ′ | *Pounds.* |
| Apr. 3 | P. M. | 59 | 1,059 | Du Pont's black prismatic. O. I. N.: density, 1.800; 151 prisms in each cartridge; 12 prisms in cross section. | 14 0 | Shell rebanded. | 43 0<br>2 0 sand.<br>45 0 | 5 00 | .............. |
| | | 60 | 1,060 | | 14 0 | | 41 0<br>4 0 sand.<br>45 0 | 5 00 | .............. |
| | | 61 | 1,061 | | 14 0 | | 45 0 natural weight. | 5 00 | .............. |
| | | 62 | 1,062 | | 14 0 | | 43 0<br>2 0 sand.<br>45 0 | 5 00 | .............. |
| | | 63 | 1,063 | | 14 0 | | 43 0<br>2 0 sand.<br>45 0 | 5 00 | .............. |
| | | 64 | 1,064 | | 14 0 | | 44 8<br>8 sand.<br>45 0 | 10 00 | .............. |
| | | 65 | 1,065 | | 14 0 | | 41 8<br>3 8 sand.<br>45 0 | 10 00 | .............. |
| | | 66 | 1,066 | | 14 0 | | 43 0<br>2 0 sand.<br>45 0 | 10 00 | .............. |
| | | 67 | 1,067 | | 14 0 | | 45 0 natural weight. | 10 00 | .............. |
| | | 68 | 1,068 | | 14 0 | | 45 0 natural weight. | 10 00 | .............. |
| May 1 | A. M. | 69 | 1,069 | Du Pont's black prismatic. O. I. N.; density, 1.800; 151 prisms in each cartridge; 12 prisms in cross section. | 14 0 | Shell rebanded. | 45 0 natural weight. | 5 00 | .............. |
| | | 70 | 1,070 | | 14 0 | | 45 0 natural weight. | 5 00 | .............. |
| | | 71 | 1,071 | | 14 0 | | 45 0 natural weight. | 5 00 | .............. |
| | | 72 | 1,072 | | 14 0 | | 45 0 natural weight. | 5 00 | .............. |
| | | 73 | 1,073 | | 14 0 | | 45 0 natural weight. | 5 00 | .............. |
| | | 74 | 1,074 | | 14 0 | | 39 0<br>6 0 sand.<br>45 0 | 10 00 | .............. |
| | | 75 | 1,075 | | 14 0 | | 38 0<br>7 0 sand.<br>45 0 | 10 00 | .............. |
| | | 76 | 1,076 | | 14 0 | | 45 0 natural weight. | 10 00 | .............. |
| | | 77 | 1,077 | | 14 0 | | 42 0<br>3 0 sand.<br>45 0 | 10 00 | .............. |

*Arsenal, at Sandy Hook, N. J., from April 3 to May 1, 1891.*

of siege-gun carriage.]

| Recoil. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|
| | Gun mounted on new 5-inch steel siege carriage, with hydraulic buffer. Received from Watervliet Arsenal December 8, 1890. Obturating friction primers. | |
| *Inches.*<br>24¾ | | |
| 25⅛ | | |
| 24½ | | |
| 25⅛ | | |
| 25⅜ | | |
| | Fired down the beach. Aimed to the left of 1-mile target. | |
| 29⅝ | Broken bolt in left cheek of carriage replaced by new one before this firing. | |
| 28⅞ | | |
| 28¾ | After this firing it was found that the recess in left side of carrier ring was badly burred. | Breechblock opened with difficulty. |
| 28¾ | Elevating screw found burred. Burrs removed .... | Front cut wiped off. Breechblock opened easily. |
| 29½ | | |
| | Firing conducted by Lieut. C. B. Wheeler, O. D., assistant proof officer. | |
| | Gun mounted on new 5-inch steel siege carriage with hydraulic buffer. Received from Watervliet Arsenal December 8, 1890. Obturating friction primers. | |
| 24½ | | |
| 24⅜ | | |
| 24⅛ | | |
| 25 | .................................................... | Lanyard broke. |
| 23⅛ | | |
| 29 | Since last firing a piece of steel 1¾ inches long, 11/16 of an inch wide, and 7/16 of an inch thick was dovetailed into left side of recess in carrier ring.<br>Fired down the beach. Aimed to the left of 1-mile target. | |
| 28 | | |
| 29 | Two new brass boxes fitted to elevating shaft before this firing. | |
| 28 | | |

*Record of firing with 5-inch B. L. siege rifle (steel), No. 1, Watertown*

[Object of firing, to test

| Date. | | No. of fire with carriage. | No. of fire. | Powder. Kind. | Powder. Weight | Projectile. Kind. | Projectile. Weight. | Elevation. | Pressure per square inch of bore. |
|---|---|---|---|---|---|---|---|---|---|
| 1891. | | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ′ | *Pounds.* |
| May 1 | A.M. | 78 | 1,078 | Du Pont's black prismatic, O. I. N.; density, 1.800; 151 prisms in each cartridge; 12 prisms in cross section. | 14 0 | Shell rebanded. | 43 0<br>2 0 sand.<br>45 0 | 10 00 | |
| | | 79 | 1,079 | | 14 0 | | 43 0<br>2 0 sand.<br>45 0 | 10 00 | |
| | | 80 | 1,080 | | 14 0 | | 44 0<br>1 0 sand.<br>45 0 | 10 00 | |
| | | 81 | 1,081 | | 14 0 | | 44 0<br>1 0 sand.<br>45 0 | 10 00 | |
| | | 82 | 1,082 | | 14 0 | | 45 0 natural weight. | 10 00 | |
| | | 83 | 1,083 | | 14 0 | | 45 0 natural weight. | 10 00 | |
| May 12 | | 84 | 1,084 | Du Pont's black prismatic, O. I. N.; density, 1.800; 151 prisms in each cartridge; 12 prisms in cross section. | 14 0 | Shell rebanded. | 45 0 natural weight. | 10 0 | |
| | | 85 | 1,085 | | 14 0 | | 45 0 natural weight. | 10 0 | |
| | | 86 | 1,086 | | 14 0 | | 45 0 natural weight. | 10 0 | |
| | | 87 | 1,087 | | 14 0 | | 45 0 natural weight. | 10 0 | |
| | | 88 | 1,088 | | 14 0 | | 45 0 natural weight. | 10 0 | |
| | | 89 | 1,089 | | 14 0 | | 43 0<br>2 0 sand.<br>45 0 | 10 0 | |
| | | 90 | 1,090 | | 14 0 | | 45 0 natural weight. | 15 0 | |
| | | 91 | 1,091 | | 15 0 | | 45 0 natural weight. | 15 0 | |
| Aug. 3 | A.M. | 92 | 1,092 | Du Pont's black prismatic, O. I. N.; density, 1.800; 151 prisms in each cartridge; 12 prisms in cross section. | 14 0 | Shell rebanded. | 45 0 natural weight. | 5 00 | No. 1, 38,300 |
| | | 93 | 1,093 | | 14 0 | | 41 0<br>4 0 sand.<br>45 0 | 5 00 | No. 1, 35,950 |
| | | 94 | 1,094 | | 14 0 | | 45 0 natural weight. | 5 00 | |
| | | 95 | 1,095 | | 14 0 | | 43 0<br>2 0 sand.<br>45 0 | 5 00 | |
| | | 96 | 1,096 | | 14 0 | | 45 0 natural weight. | 5 00 | |
| | | 97 | 1,097 | | 14 0 | | 42 9<br>2 7 sand.<br>45 0 | 10 00 | No. —, 35,910 |

*Arsenal, at Sandy Hook, N. J., from May 1 to August 3, 1891.*

**5 inch siege carriage.]**

| Recoil. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data |
|---|---|---|
| *Inches.* | Gun mounted on new 5-inch steel siege carriage, with hydraulic buffer. Received from Watervliet Arsenal December 8, 1890. Obturating friction primers, model 1887. | |
| 28½ | | |
| 29 | | Slight leakage at front end of cylinder in stuffing box. |
| 28½ | Fired down the beach. Aimed to the left of 1-mile target. | Lanyard broke. Primer failed. |
| 28½ | | |
| 29 | | Lower bolt on left-hand side of transom broken.<br>Piston rod broke at beginning of threads near lug on carriage. |
| ........ | Firing conducted by Lieut. C. B. Wheeler, O. D., assistant proof officer.<br>Gun mounted on new steel siege carriage, with hydraulic buffers. Received from Watervleit Arsenal December 8, 1890. | |
| 29½ | | Piston rod scratched, and slightly bent. |
| 29½ | | |
| 29 | | |
| 29 | | |
| 29½ | Before this firing a new piston rod, made of wrought iron, was put in cylinder.<br>2½ gallons of oil in cylinder.<br>Fired to sea.<br>Obturating friction primers. | |
| 29 | | |
| - | | |
| 32 | | Piston rod broke at beginning of threads near lug on carriage; carriage turned completely over sideways, due to running off platform. |
| ........ | Firing conducted by Lieut. C. B. Wheeler, O. D., assistant proof officer.<br>Gun mounted on new steel siege carriage, with hydraulic buffer. Received from Watervliet Arsenal December 8, 1890. | |
| 25½ | | |
| 24¾ | | |
| 25 | Before this firing a new piston rod made of steel was put in cylinder, edges of stuffing box of cylinder rounded off, threaded end of piston rod increased in diameter ½ inch. Bore and thread in crosshead of cylinder enlarged to correspond and deepened ½ inch.<br>2½ gallons of oil in cylinder. | Piston rod beginning to score. |
| 25 | | |
| 25 | | |
| 32 | | Cylinder at rear end leaked slightly after this round. |

*Record of firing with 5-inch B. L. siege rifle (steel), No. 1,*

**Object of firing, test of**

| Date. | | No. of fire with carriage. | No. of fire. | Powder. | | Projectile. | | Elevation. | Pressure per square inch of bore. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Kind. | Weight | Kind. | Weight. | | |
| 1891. | | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ′ | *Pounds.* |
| Aug. 3 | A. M. | 98 | 1,098 | Du Pont's black prismatic, O. L. N.; density, 1.800; 151 prisms in each cartridge, 12 prisms in cross section. | 14 0 | Shell rebanded. | 45 0 | 10 00 | |
| | | 99 | 1,099 | | 14 0 | | 41 0<br>4 0 sand.<br>45 0 | 10 00 | |
| | | 100 | 1,100 | | 14 0 | | 41 0<br>4 0 sand.<br>45 0 | 10 00 | |
| | | 101 | 1,101 | | 14 0 | | 45 0 natural weight. | 15 00 | |
| Aug. 3 | P. M. | ...... | 1,102 | | 14 0 | | 43 0<br>2 0 sand.<br>45 0 | 15 00 | |
| | | 103 | 1,103 | | 14 0 | | 42 0<br>3 0 sand.<br>45 0 | 15 00 | |
| | | 104 | 1,104 | | 14 0 | | 41 0<br>4 0 sand.<br>45 0 | 15 00 | |
| | | 105 | 1,105 | | 14 0 | | 43 0<br>2 0 sand.<br>45 0 | 15 00 | |
| | | 106 | 1,106 | | 14 0 | | 42 0<br>3 0 sand.<br>45 0 | 15 00 | |
| | | 107 | 1,107 | | 14 0 | | 41 0<br>4 0 sand.<br>45 0 | 15 00 | |
| | | 108 | 1,108 | | 14 0 | | 43 0<br>2 0 sand.<br>45 0 | 15 00 | |
| | | 109 | 1,109 | | 14 0 | | 41 0<br>4 0 sand.<br>45 0 | 15 00 | |
| | | 110 | 1,110 | | 14 0 | | 41 8<br>3 8 sand.<br>45 0 | 15 00 | |
| | | 111 | 1,111 | | 14 0 | | 41 0<br>4 0 sand.<br>45 0 | 15 00 | |
| | | 112 | 1,112 | | 14 0 | | 41 8<br>3 8<br>45 0 | 15 00 | |
| | | 113 | 1,113 | | 14 0 | | 42 0 sand.<br>3 0<br>45 0 | 15 00 | |

*Watertown Arsenal, at Sandy Hook, N. J., August 3, 1891.*

siege-gun carriage.]

| Recoil. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|
| | Gun mounted on new steel siege carriage, with hydraulic buffer. Received from Watervliet Arsenal December 8, 1890. | |
| *Inches.* | | |
| 31⅛ | | |
| 32⅛ | | |
| 31⅜ | | |
| 32⅜ | | |
| 32⅛ | | |
| 33⅛ | | |
| 33⅛ | | Leakage at rear end of cylinder increasing. |
| 33⅛ | | |
| 33⅛ | Copper cylinders of 32,000 pounds initial compression and tables of 1890.<br>Fired to sea.<br>Obturating friction primers.<br>Cylinder leakage 1 pint in 12 rounds. | One pint of oil added before this round. |
| 33⅜ | | |
| 33⅜ | | |
| 33⅛ | | |
| 33⅜ | | |
| 33⅜ | | Fifth nut from rear on right-hand side of trail broke. |
| 33⅜ | | |
| 33⅜ | | |

*Record of firing with 5-inch B. L. siege rifle (steel), No. 1, Watertown*

[Object of firing, test

| Date. | | No. of fire with carriage. | No. of fire. | Powder. | | Projectile. | | Elevation. | Pressure per square inch of bore. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Kind. | Weight | Kind. | Weight. | | |
| 1891. | | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ′ | *Pounds.* |
| Aug. 3 | P. M. | 114 | 1,114 | Du Pont's black prismatic, O. I. N.; density, 1.800; 151 prisms in each cartridge; 12 prisms in cross section. | 14 0 | Shell rebanded. | 42 0<br>3 0 sand.<br>45 0 | 15 00 | ............... |
| | | 115 | 1,115 | | 14 0 | | 42 0<br>3 0 sand.<br>45 0 | 15 00 | ............... |
| | | 116 | 1,116 | | 14 0 | | 42 0<br>3 0 sand.<br>45 0 | 15 00 | No. 1, 38,200 |
| | | 117 | 1,117 | | 14 0 | | 45 0 natural weight. | 15 00 | ............... |
| | | 118 | 1,118 | | 14 0 | | 45 0 natural weight. | 15 00 | ............... |
| | | 119 | 1,119 | | 14 0 | | 42 8<br>2 8 sand.<br>45 0 | 15 00 | No. 1, 36,320 |
| | | 120 | 1,120 | | 14 0 | | 45 0 natural weight. | 15 00 | ............... |
| Aug. 4 | A. M. | 121 | 1,121 | Du Pont's black prismatic, O. I. N.; density, 1.800; 151 prisms in each cartridge, 12 prisms in cross section. | 14 0 | Shell rebanded. | 45 0 natural weight. | 15 00 | ............... |
| | | 122 | 1,122 | | 14 0 | | 42 0<br>3 0 sand.<br>45 0 | 15 00 | ............... |
| | | 123 | 1,123 | | 14 0 | | 41 0<br>4 0 sand.<br>45 0 | 15 00 | ............... |
| | | 124 | 1,124 | | 14 0 | | 41 0<br>4 0 sand.<br>45 0 | 15 00 | ............... |
| | | 125 | 1,125 | | 14 0 | | 45 0 natural weight. | 15 00 | ............... |
| | | 126 | 1,126 | | 14 0 | Shell (banded), experimental. Lot 307. Weighted up with sand. | 41 4<br>3 12 sand.<br>45 0 | 15 00 | ............... |
| | | 127 | 1,127 | | 14 0 | | 42 0<br>3 0 sand.<br>45 0 | 15 00 | ............... |
| | | 128 | 1,128 | | 14 0 | | 41 15<br>3 1 sand.<br>45 0 | 15 00 | ............... |
| | | 129 | 1,129 | | 14 0 | | 41 4<br>3 12 sand.<br>45 0 | 20 00 | No. 1, 34,600 |

*Arsenal, at Sandy Hook, N. J., from August 3 to August 4, 1891.*

of siege-gun carriage.]

| Recoil. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|
| *Inches.* | Gun mounted on new steel siege carriage, with hydraulic buffer. Received from Watervliet Arsenal December 8, 1890. | |
| 33¾ | | Breechblock opened with difficulty. |
| 33¾ | | |
| 33¾ | | Fourth rivet in bottom of trail right hand side broken; fracture showed the rivet had been partly broken some time. |
| | Leakage of cylinder occurs at the moment of completion of return of carriage to battery.<br>Fired to sea. | |
| 33⅛ | Copper cylinders of 32,000 pounds initial compression and tables of 1890. | |
| 33⅛ | | |
| 33¾ | | |
| 33¾ | | |
| | Firing conducted by Lieut. W. W. Gibson, O. D., assistant proof officer.<br>Gun mounted on new 5-inch steel siege carriage with hydraulic buffer. Received from Watervliet Arsenal, December 8, 1890.<br>Obturating friction primers. | |
| 30 | | |
| 32½ | | |
| 32⅛ | | Two primers failed; wires of primers pulled out. |
| 32 | | Two primers failed; wires of primers pulled out. |
| 32¾ | | |
| | Fired to sea | |
| 32⅛ | | |
| 32 | | |
| 32½ | | One and one-half pints of oil added to cylinder. |
| 34 | | |

*Record of firing with 5-inch B. L. siege rifle (steel), No. 1,*

| Date. | | No. of fire with carriage. | No. of fire. | Powder. | | Projectile. | | Elevation. | Pressure per square inch of bore. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Kind. | Weight | Kind. | Weight. | | |
| 1891. | | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ′ | *Pounds.* |
| Aug. 4 | A. M. . . | 130 | 1,130 | Du Pont's black prismatic, O. I. N.; density 1.800; 151 prisms in each cartridge; 12 prisms in cross section. | 14 0 | Shell (banded), experimental. Lot 307. Weighted up with sand. | 41 11<br>3 5 sand.<br>45 0 | 20 00 | . . . . . . . . . . . . . . . |
| | | 131 | 1,131 | | 14 0 | | 41 10<br>3 6 sand.<br>45 0 | 20 00 | . . . . . . . . . . . . . . |
| | | 132 | 1,132 | | 14 0 | | 41 5<br>3 11 sand.<br>45 0 | 20 00 | . . . . . . . . . . . . . . |
| | | 133 | 1,133 | | 14 0 | | 41 5<br>3 11 sand.<br>45 0 | 20 00 | . . . . . . . . . . . . . . |
| | | 134 | 1,134 | | 14 0 | | 41 8<br>3 8 sand.<br>45 0 | 20 00 | . . . . . . . . . . . . . . |
| | | 135 | 1,135 | | 14 0 | | 41 8<br>3 8 sand.<br>45 0 | 20 00 | . . . . . . . . . . . . . . |
| | | 136 | 1,136 | | 14 0 | | 41 13<br>3 3 sand.<br>45 0 | 20 00 | . . . . . . . . . . . . . . |
| | | 137 | 1,137 | | 14 0 | | 41 11<br>3 5 sand.<br>45 0 | 20 00 | . . . . . . . . . . . . . . |
| | | 138 | 1,138 | | 14 0 | | 41 8<br>3 8 sand.<br>45 0 | 20 00 | . . . . . . . . . . . . . . |
| | | 139 | 1,139 | | 14 0 | | 41 6<br>3 10 sand.<br>45 0 | 20 00 | . . . . . . . . . . . . . . |
| | | 140 | 1,140 | | 14 0 | | 41 7<br>3 9 sand.<br>45 0 | 20 00 | . . . . . . . . . . . . . . |
| | | 141 | 1,141 | | 14 0 | | 41 15<br>3 1 sand.<br>45 0 | 20 00 | . . . . . . . . . . . . . . |
| | | 142 | 1,142 | | 14 0 | | 41 10<br>3 6 sand.<br>45 0 | 20 00 | . . . . . . . . . . . . . . |
| | | 143 | 1,143 | | 14 0 | | 41 5<br>3 11 sand.<br>45 0 | 20 00 | . . . . . . . . . . . . . . |
| | | 144 | 1,144 | | 14 0 | | 41 13<br>3 3 sand.<br>45 0 | 20 00 | . . . . . . . . . . . . . . |

*Watertown Arsenal, at Sandy Hook, N. J., August 4, 1891.*

| Recoil. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|
| *Inches.* | Gun mounted on new 5-inch steel siege carriage, with hydraulic buffer. Received from Watervliet Arsenal December 8, 1890. Obturating friction primers. | |
| 34 | Fired to sea | |
| 34½ | | |
| 34 | | |
| 33¾ | | |
| 33¾ | | |
| 33½ | | |
| 30½ | | |
| 33½ | | First primer failed; wires of primer pulled out. |
| 33½ | | |
| 34 | | One and one-half pints of oil added to cylinder. |
| 33¾ | | |
| 34 | | |
| 33¾ | | |
| 34 | | |
| 33¾ | | |

*Record of firing with 5-inch B. L. siege rifle (steel), No. 1, Watertown*

| Date. | | No. of fire with carriage. | No. of fire. | Powder. | | Projectile. | | Elevation. | Pressure per square inch of bore. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Kind. | Weight | Kind. | Weight. | | |
| 1891. | | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ′ | *Pounds.* |
| Aug. 4 | A. M... | 145 | 1,145 | Du Pont's black prismatic, O. I. N.; density, 1.800; 151 prisms in each cartridge; 12 prisms in cross section. | 14 0 | Shell (banded), experimental. Lot 307. Weighted up with sand. | 41 5<br>3 11 sand.<br>45 0 | 20 00 | ............... |
| | | 146 | 1,146 | | 14 0 | | 41 8<br>3 8 sand.<br>45 0 | 20 00 | ............... |
| | | 147 | 1,147 | | 14 0 | | 41 4<br>3 12 sand.<br>45 0 | 20 00 | ............... |
| | | 148 | 1,148 | | 14 0 | | 41 5<br>3 11 sand.<br>45 0 | 20 00 | ............... |
| | | 149 | 1,149 | | 14 0 | | 41 14<br>3 2 sand.<br>45 0 | 20 00 | ............... |
| | | 150 | 1,150 | | 14 0 | | 41 8<br>3 8 sand.<br>45 0 | 20 00 | ............... |
| Aug. 4 | P. M.... | 151 | 1,151 | | 14 0 | | 41 11<br>3 5 sand.<br>45 0 | 20 00 | ............... |

*Arsenal, at Sandy Hook, N. J., August 4, 1891*—Continued.

| Recoil. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|
| *Inches.* | Gun mounted on new 5-inch steel siege carriage, with hydraulic buffer. Received from Watervliet Arsenal December 8, 1890. | |
| 34 | | |
| 34 | | |
| 33⅛ | | |
| 33⅜ | Fired to sea | |
| 33 | | |
| 33 | | Key of elevating shaft driven out. |
| 33¼ | | New key put in elevating shaft. One pint of oil added to cylinder. Piece broken out of cam of lever handle. |
| | Firing conducted by Lieut. W. W. Gibson, O. D., assistant proof officer. | |

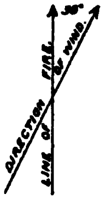
*Record of firing with 5-inch B. L. rifle (steel), No. 1,*

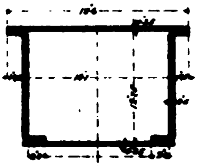
**[Object of firing, test**

| Date. | | No. of fire with carriage. | No. of fire. | Powder. Kind. | Powder. Weight. | Projectile. Kind. | Projectile. Weight. | Projectile. Including sand. | Elevation. | Pressure per square inch of bore. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1891. | | | | | *Lbs.* | | *Lbs.* | *Lbs. Oz.* | ° ′ | *Pounds.* |
| Aug. 13 | A. M. | 152 | 1,152 | Du Pont's black prismatic, O. I. N.; density, 1.800; 151 prisms in each cartridge; 12 prisms in cross section. | 14 | Shell (banded), experimental. Lot 307. | 45 | 3 0 | 20 00 | |
| | | 153 | 1,153 | | 14 | | 45 | 3 0 | 20 00 | |
| | | 154 | 1,154 | | 14 | | 45 | 3 0 | 20 00 | |
| | | 155 | 1,155 | | 14 | | 45 | 3 0 | 20 00 | |
| | | 156 | 1,156 | | 14 | | 45 | 2 9 | 20 00 | |
| | | 157 | 1,157 | | 14 | | 45 | 3 1 | 20 00 | |
| | | 158 | 1,158 | | 14 | | 45 | 3 7 | 20 00 | |
| | | 159 | 1,159 | | 14 | | 45 | 3 11 | 25 00 | No. 1—35,300 |
| | | 160 | 1,160 | | 14 | | 45 | 3 11 | 25 00 | |
| | | 161 | 1,161 | | 14 | | 45 | 3 0 | 25 00 | |
| | | 162 | 1,162 | | 14 | | 45 | 3 0 | 25 00 | |
| | | 163 | 1,163 | | 14 | | 45 | 3 4 | 25 00 | |
| | | 164 | 1,164 | | 14 | | 45 | 3 5 | 25 00 | |
| | | 165 | 1,165 | | 14 | | 45 | 2 10 | 25 00 | |
| | | 166 | 1,166 | | 14 | | 45 | 3 6 | 25 00 | |
| | | 167 | 1,167 | | 14 | | 45 | 3 6 | 25 00 | |
| | | 168 | 1,168 | | 14 | | 45 | 3 4 | 25 00 | |
| | | 169 | 1,169 | | 14 | | 45 | 3 8 | 25 00 | |
| | | 170 | 1,170 | | 14 | | 45 | 3 4 | 25 00 | |
| | | 171 | 1,171 | | 14 | | 45 | 3 7 | 25 00 | |
| | | 172 | 1,172 | | 14 | | 45 | 3 7 | 25 00 | |
| | | 173 | 1,173 | | 14 | | 45 | 3 1 | 25 00 | |
| | | 174 | 1,174 | | 14 | | 45 | 3 8 | 25 00 | |
| | | 175 | 1,175 | | 14 | | 45 | 3 0 | 25 00 | |
| Aug. 13 | P. M. | 176 | 1,176 | | 14 | | 45 | 3 6 | 25 00 | |
| | | 177 | 1,177 | | 14 | | 45 | 3 5 | 25 00 | |
| | | 178 | 1,178 | | 14 | | 45 | 3 4 | 25 00 | |
| | | 179 | 1,179 | | 14 | | 45 | 3 4 | 30 00 | |
| | | 180 | 1,180 | | 14 | | 45 | 2 9 | 30 00 | |
| | | 181 | 1,181 | | 14 | | 45 | 3 1 | 30 00 | |
| | | 182 | 1,182 | | 14 | | 45 | 3 2 | 30 00 | |
| | | 183 | 1,183 | | 14 | | 45 | 3 0 | 30 00 | |
| | | 184 | 1,184 | | 14 | | 45 | 3 6 | 30 00 | |
| | | 185 | 1,185 | | 14 | | 45 | 3 11 | 30 00 | |
| | | 186 | 1,186 | | 14 | | 45 | 3 8 | 30 00 | |
| | | 187 | 1,187 | | 14 | | 45 | 3 8 | 30 00 | |
| | | 188 | 1,188 | | 14 | | 45 | 3 10 | 30 00 | |

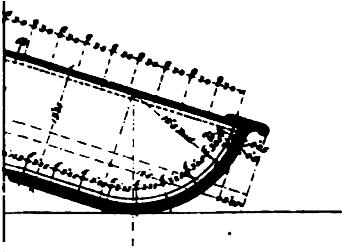
*Watertown Arsenal, at Sandy Hook, N. J., August 13, 1891.*

of siege-gun carriage.]

| Recoil. | Wind, strength and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|
| | | Gun mounted on 5-inch steel siege carriage, with hydraulic buffer. Received from Watervliet Arsenal December 8, 1890. | |
| *Inches.*<br>33 | Six miles an hour. | | |
| | | Obturating friction primers. | |
| 33⅛ | | | |
| 33 | | | |
| 33⅛ | | .................................... | Left side of cam burred slightly after this round. |
| 33½ | | | |
| 33 | | | |
| 33⅛ | | Since last firing a piece of steel has been dovetailed in cam of lever handle. | |
| 32½ | | .................................... | Copper cylinder of 32,000 pounds initial compression and tables of 1890. |
| 31¼ | | | |
| 30¾ | | .................................... | At moment of returning cylinder head to battery; cylinder leaked freely. |
| 31 | | Fired to sea. | |
| 31 | | .................................... | One pint of oil added to cylinder. |
| 32⅛ | | Leakage at rear head of cylinder continues at the moment of completion of carriage to battery. | Seventh rivet in left side of trail broken. Fracture showed rivet to be defective. |
| 32⅛ | | | |
| 32½ | | | |
| 32 | | | |
| 31⅛ | | | |
| 32 | | | |
| 31⅛ | | | |
| 31⅛ | | | |
| 31⅛ | | | |
| 32 | | Obturating friction primers. | |
| 32 | | | |
| 31⅛ | | | |
| 33 | | | |
| 33 |  | | |
| 33 | | Fired to sea. | |
| 33 | | | |
| 32⅛ | | | |
| 32 | | | |
| 32 | | | |
| 31 | | | |
| 31 | | | |
| 31 | | | |
| 31 | | | |
| 31 | | | |
| 31 | | | |
| | | Firing conducted by Lieut. W. W. Gibson, O. D., assistant proof officer. | |



Transverse Section at a.



Charles Shaler
Captain of Ordnance

# APPENDIX 36.

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## REPORT ON TESTS OF HOTCHKISS 3.2-INCH SHRAPNEL.

(Twenty-one plates.)

SANDY HOOK PROVING GROUND,
*September 28, 1891.*

SIR: I have the honor to report that, in compliance with instructions from your office dated May 12, 1891, I have made the necessary firing tests of fifty 3.2-inch Hotchkiss shrapnel received at this post for trial. These shrapnel have the chamber for bursting charge in front, and very brittle cast-iron separators between the balls. There are 9 separators in all; in 7 of them hemispherical cavities, slightly larger in diameter than the balls, are formed in their upper and lower surfaces; they are also further weakened by 6 radial cuts extending nearly to the center. These cuts are not formed in the separator, which is located in the same cross section as the band of the projectile, and the bottom separator has cavities only on its upper surface. The balls are inclosed in the hollow spheres formed by the two contiguous separators. There are 7, layers of 18 balls each, or 162 balls in all. The diameter of the balls is half an inch. They are made of a composition of 90 per cent lead and 10 per cent antimony; weight of each ball, about 280 grains. The body of the shrapnel is composed of three parts, the cast-iron head or grenade containing the chamber space for a bursting charge of 3 ounces rifle powder, the cast-steel base, and the wrought-iron cylinder. These parts are screwed together, and it is understood that by shrinkage the cylinder is made to compress the separators so as to produce in them initial cracks. Longitudinal grooves are cut in the cylinders to facilitate breaking up.

If we assume that a segment of a separator could be broken into two parts, each "A" separator could furnish 13 fragments, including the central circular portion, the "C" separator would furnish 7, and the "B" 1, or 109 fragments in all, including base, cylinder (6 fragments), grenade, fuse, and band. The number of balls is 162; therefore the maximum number of balls and fragments available from each shrapnel is 271.

The tests were conducted to determine generally the value of this shrapnel for service, and also with a view to a comparison of the results with those obtained with shrapnel having the bursting charge in rear and balls imbedded in plaster of Paris.

A range of 4,000 yards was considered the maximum necessary at which to test the efficiency of the shrapnel, and in order that the results might be affected as little as possible by elements not due to the shrapnel themselves, a sensitive-point percussion fuse, specially prepared at Frankford Arsenal, was used throughout the tests, the time bursts being caused by firing through a 1-inch board screen placed at the required distance in front of the targets to be hit. In this manner the action of a perfect time fuse was assimilated.

The weight of the shrapnel, including fuse and bursting charge, was 13 pounds 6 ounces, and as the position of the band was 1.25 inches from the base, the charge was reduced 1 ounce as compared with the charge used with common shell, in which the bend is 0.625 inch from the base, and the chamber space is correspondingly greater.

The following tests were conducted as required by the instructions:

(1) Firings with full charges at a range of 1,000 yards to determine the cone of dispersion, the screen being placed at such distance in front of the target that the pattern will be defined on the target. For this a screen of 1-inch boards, 18 by 13 feet, was placed 115 feet in front of the 1,000-yards target, the dimensions of which were 11 by 52 feet. In this, as in all other tests, various sighting shots were taken, using the charge of 3 pounds 11 ounces and common shell weighted to 13 pounds 6 ounces. Four shrapnel were fired, 1 of which missed. The screen was then moved to 90 feet from target and 2 shrapnel fired. The results are shown in Table I, and also in the plotted targets attached to this report. With the screen 115 feet from target, 257 hits were obtained with 3 shrapnel, or about 30 per cent of the maximum. At 90 feet the number of hits with 2 shrapnel was 237, or 43 per cent of the maximum. (See also Test 3.)

(2) Firings through a screen for time bursts with full charges, at a series of targets at ranges of 1,760 and 3,000 yards, to determine number of hits and penetration. For the mile range the screen was made 24 by 40 feet, and the targets, four in number, each 6 by 52 feet, were so placed that the distances between screen and targets, respectively, were 75 feet. Seven schrapnel were fired, 3 being lost. The results are arranged in Table II. The total number of hits was 601, or 56 per cent of the maximum. At 3,000 yards the screen, 30 by 40 feet, and targets, 6 by 52 feet, were placed at intervals of 60 feet. Eleven shrapnel were fired at this range, of which 6 were ineffective. Of these six, 1 was lost by striking the telegraph wires and bursting about 60 feet in front of gun; 2 were percussion bursts in front of screen; 2 broke up in gun, and 1 missed targets and screen and struck the ground without bursting. The two percussion bursts were both peculiar in their action. The first struck ground 6 feet in front of screen; it then burst and fragments expended their force by cutting and tearing away the lower boards of screen, but few fragments being found in first or second targets. The second struck the ground 25 feet in front of screen. It burst into very few fragments, and a large portion of the shrapnel was picked up entire. The grenade, fuse, and "B" separator were gone, but a large portion of the cylinder still adhered to the base, and by bending over at its forward end held between it and the base a large number of balls and small fragments. With the 5 effective shrapnel 844 hits were obtained, or 62 per cent of the number possible. The results are arranged in Tables II and III.

(3) Firing through a screen, with reduced charges, against a large target at short range, to assimilate a range of 4,000 yards with full charges, to determine principally the penetration power of the balls and fragments at that range.

For this test the charge used was 15 ounces, corresponding to a calculated velocity of 760 feet. The gun was placed 75 feet from screen and the latter 75 feet from target. The target was increased in height to 16 feet and the results are contained in Table IV. These results, in connection with the first test, assist in forming an idea of the nature of the cone of dispersion produced by the bursting of these shrapnel. The depth of penetration varied from part of an inch to 1½ inches, as shown by the table.

(4) Firings for percussion bursts on striking ground in front of a large target with full charges at a range of 1 mile. Seven shrapnel were used in this test, but only 2 effective shots were obtained. The first struck the ground 70 yards in front of target, and 63 hits were obtained; the second about 25 yards nearer, and 140 hits were recorded, as shown in Table V.

Throughout these tests the firings were conducted in a very skillful manner by Lieut. W. W. Gibson, Ordnance Department.

## CONCLUSIONS.

An examination of the results obtained in these tests, as exhibited in the tables and drawings appended, shows that these shrapnel possess a high order of merit as regards bursting effect for ranges up to 4,000 yards, both with respect to the number of balls and fragments produced and their effectiveness. The greater proportion of the balls and fragments entire passed through or were imbedded in the targets, and were well distributed over them. The "indents" were not sufficient to produce dangerous wounds.

Of the 34 shrapnel fired 6 broke up in the gun. An improvement in the design of the shrapnel or in the quality of the material used in its construction appears to be desirable. The only weakness observable in the design is due to cutting away the material of the cylinder to make place for the band. It may be that the breaking up is due to faulty construction at this point.

Incidentally, the accuracy of these shrapnel at the various ranges was determined as compared with the service projectiles for 3.2-inch rifle. In general it may be said that the accuracy, while fair, was not as good as with the latter. Uniformly the elevation required was greater, the flight of the projectile was somewhat more erratic, and was not quite as smooth and regular as with the service projectile.

Very respectfully, your obedient servant,

FRANK HEATH,
*Captain, Ord. Dept., U. S. Army, Commanding.*

The CHIEF OF ORDNANCE, U. S. ARMY,
*Washington, D. C.*

(6646-'91.)

NOTE.—Since the date of the above report thirteen shrapnel have been fired, ten of them for accuracy at the mile target, as compared with the accuracy of an equal number of service projectiles. Throughout these firings no fuses were used, and none of the shrapnel broke up in the gun, from which it may be inferred that at least a portion of the six premature explosions recorded in report were due to the extreme sensitiveness of the fuses used, rather than to any fault of material or construction in the shrapnel. The mean deviation of the shrapnel from the center of impact was 2.9 feet, while that of the service shell was 4.32 feet; with the shrapnel, however, there were four misses, which were not taken into account in calculating the mean deviation. The center of impact was very low on the target; if it had been brought higher by using a greater angle of elevation these misses would probably not have occurred, but the deviation would have been greater than 2.9 feet. With the service shell there were no misses, the angle of elevation being the same, and in all cases it was noted that a greater elevation was required for the shrapnel than for the shell. The performance of the shrapnel was, however, excellent, and indicates that the word "fair," as used in the report, does not adequately express the actual value of the shrapnel as regards accuracy.

**Frank Heath,**
*Captain, Ord. Dept., U. S. Army.*

(8128–'91.)

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TABLE I.—*Results with five Hotchkiss 3.2-inch shrapnel, to determine cone of dispersion, etc.*

[Screen 18 by 13 feet, 115 and 90 feet from target and 1,000 yards from gun.]

| | Point struck, from center of screen. | | | Hits. | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Balls. | | | Fragments. | | | |
| | Above. | Right. | Left. | Through. | Embedded. | Indents. | Through. | Embedded. | Indents. | Total. |
| Target 115 feet from screen: | *Feet.* | *Feet.* | *Feet.* | | | | | | | |
| Shrapnel No. 1 | 3½ | ...... | 5 | 51 | 1 | 4 | 23 | 4 | 0 | 83 |
| Shrapnel No. 3 | 4½ | 2 | ...... | 64 | 0 | 2 | 21 | 9 | 2 | 98 |
| Shrapnel No. 4 | 7 | 1 | ...... | 52 | 0 | 4 | 14 | 6 | 0 | 76 |
| Target 90 feet from screen: | | | | | | | | | | |
| Shrapnel No. 5 | 3 | ...... | 1½ | 73 | 12 | 0 | 27 | 3 | 0 | 115 |
| Shrapnel No. 6 | 5 | 1½ | ...... | 81 | 17 | 0 | 19 | 4 | 1 | 122 |
| Total with 5 shrapnel | ...... | ...... | ...... | 321 | 30 | 10 | 104 | 26 | 3 | 494 |

Shrapnel No. 2 missed screen and target; struck ground in rear and burst.

**TABLE II.**—*Result with four Hotchkiss 3.2-inch shrapnel to determine number of hits, penetration, etc.*

[Screen 40 by 24 feet; screen and targets 25 yards apart and 1,760 yards from gun.]

| | Point struck, from center of screen. | | | Hits. | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Balls. | | | Fragments. | | | |
| | Above. | Below. | Left. | Through. | Embedded. | Indents. | Through. | Embedded. | Indents. | Total. |
| | *Feet.* | *Feet.* | *Feet.* | | | | | | | |
| Shrapnel No. 1 (number of hits, 175): | | | | | | | | | | |
| First target | .... | 3 | 4 | 35 | 2 | 0 | 35 | 2 | 1 | 75 |
| Second target | | | | 45 | 4 | 2 | 10 | 4 | 8 | 73 |
| Third target | | | | 15 | 2 | 0 | 2 | 3 | 1 | 23 |
| Fourth target | | | | 4 | 0 | 0 | 0 | 0 | 0 | 4 |
| Shrapnel No. 2 (number of hits, 164): | | | | | | | | | | |
| First target | .... | 11 | 1 | 65 | 3 | 7 | 18 | 20 | 0 | 113 |
| Second target | | | | 19 | 6 | 1 | 3 | 1 | 7 | 37 |
| Third target | | | | 6 | 1 | 2 | 1 | 0 | 2 | 12 |
| Fourth target | | | | 0 | 0 | 2 | 0 | 0 | 0 | 2 |
| Shrapnel No. 5 (number of hits, 152): | | | | | | | | | | |
| First target | 6 | ...... | ...... | 9 | 0 | 6 | 3 | 10 | 0 | 28 |
| Second target | | | | 39 | 2 | 6 | 4 | 7 | 10 | 68 |
| Third target | | | | 13 | 9 | 5 | 0 | 5 | 2 | 34 |
| Fourth target | | | | 14 | 4 | 3 | 0 | 1 | 0 | 22 |
| Shrapnel No. 7 (number of hits, 110): | | | | | | | | | | |
| First target | .... | 3 | 6 | 17 | 0 | 2 | 9 | 6 | 1 | 35 |
| Second target | | | | 18 | 4 | 2 | 3 | 1 | 12 | 40 |
| Third target | | | | 8 | 4 | 2 | 4 | 1 | 2 | 21 |
| Fourth target | | | | 6 | 3 | 2 | 1 | 0 | 2 | 14 |
| Total with 4 shrapnel | ...... | ...... | ...... | 313 | 44 | 42 | 93 | 61 | 48 | 601 |

Shrapnel Nos. 3 and 6 broke in gun. Shrapnel No. 4 broke up by striking telegraph wire 50 feet from gun.

*Record of firing with 3.2-inch B. L. rifle (steel), No. 26,*

| Date. | | No. of fire. | Powder. | | Projectile. | | Elevation. | Fuse, kind. |
|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | |
| 1891. | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ′ | |
| Aug. 10 | A. M .... | 364 | Du Pont's I. K. H. Lot 4. Density, 1.725. Granulation, 2.571. | 3 11 | Shell rebanded. | 13 6 including sand. | 1 2 | |
| | | 365 | | 3 11 | Hotchkiss shrapnel. Lot 308. | 12 7 shrapnel.<br>10 fuse.<br>3 powder, bursting charge.<br>13 4 | 1 2 | Frankford Arsenal sensitive-point percussion fuse. |

*Watervliet Arsenal, at Sandy Hook, N. J., August 10, 1891.*

| Wind allowance (points right). | Wind, strength and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|
| 0 | Four miles an hour. | .......................... | Sighting shot. Struck screen 4 feet above and 4 feet 10 inches to the right of bull's-eye. |
| 0 | | Fired to burst on passing through screen, 90 feet in front of 1,000-yards target.<br>Firing conducted by Lieut. W. W. Gibson, O. D., assistant proof officer. | Shrapnel struck screen 2 feet above and 18 inches to the right of bull's-eye and burst; 122 hits on target, as follows:<br>Balls passed through target........... 81<br>Balls embedded in target.............. 17<br>Fragments through target............ 19<br>Fragments embedded in target....... 4<br>Fragment made mark................. 1<br>Total.............................. 122 |

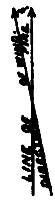
*Record of firing with 3.2-inch B. L. rifle (steel), No. 8*

**[Object of firing, to test**

| Date. | | No. of fire. | Powder. | | Projectile. | | Elevation. | Wind allowance (point right). |
|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | |
| 1891. | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ′ | |
| Aug. 19 | P. M. . | 366 | Du Pont's I. K. H. Lot 4. Density, 1,725. Granulation, 2,571. | 3 11 | Condemned shell. | 12 10<br>12 sand.<br>13 6 | 2 15 | [illegible] |
| | | 367 | | 3 11 | | 12 13<br>9 sand.<br>13 6 | 2 20 | [illegible] |
| | | 368 | | 3 11 | | 12 13<br>9 sand.<br>13 6 | 2 20 | [illegible] |
| | | 369 | | 3 11 | Hotchkiss shrapnel (lot 308), with Frankford Arsenal sensitive-point percussion fuse. | 12 7 shrapnel.<br>10 fuse.<br>3 rifle-powder, bursting charge.<br>13 4 | 2 20 | [illegible] |
| | | 370 | | 3 11 | Condemned shell. | 12 13<br>9 sand.<br>13 6 | 2 20 | [illegible] |
| | | 371 | | 3 11 | Hotchkiss shrapnel (lot 308), with Frankford Arsenal sensitive-point percussion fuse. | 13 3 shrapnel and fuse.<br>3 powder, bursting charge.<br>13 6 | 2 21 | [illegible] |

*Watervliet Arsenal, at Sandy Hook, N. J., August 19, 1891.*

**Hotchkiss shrapnel.]**

| Recoil. | Wind, strength and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|
| | | Gun mounted on Buffington steel field carriage No. 4; old spiral-spring brake on left wheel; bow-spring brake on right wheel. Cannon friction primers, model 1887. Telescopic sight used. | |
| *Feet.*<br>14 | Ten miles an hour. | | Sighting shot. Struck the ground 25 yards in rear and 10 feet to the right of screen. |
| 14 | | | Sighting shot. Struck screen 1 foot above and 12 feet left of center. |
| 14 | | | Sighting shot. Struck screen 4 feet above and 8 feet left of center. |
| 14 | | Fired to burst on passing through screen 1 mile from gun. Aimed at upper left edge of screen. Distance between each target, 75 feet. | Shrapnel struck screen 3 feet below and 4 feet left of center; burst on passing through first target, 75 feet from screen; 75 hits:<br>Balls passed through target ........... 35<br>Balls embedded in target ........... 2<br>Fragments passed through target ..... 35<br>Fragments embedded in target ........ 2<br>Fragment made mark ........ 1<br>Second target, 150 feet from screen; 73 hits:<br>Balls passed through target ........... 45<br>Balls embedded in target ........... 4<br>Balls made mark ........... 2<br>Fragments passed through target ...... 10<br>Fragments embedded in target ........ 4<br>Fragments made mark ........ 8<br>Third target, 225 feet from screen; 23 hits:<br>Balls passed through target ........... 15<br>Balls embedded in target ........... 2<br>Fragments passed through target ...... 2<br>Fragments embedded in target ........ 3<br>Fragment made mark ........ 1<br>Fourth target, 300 feet from screen; 4 hits:<br>Balls passed through target ........... 4 |
| 14 | | | Sighting shot; struck 6 feet below and on line with center of screen. |
| 14 |  | Fired to burst on passing through screen 1 mile from gun. Aimed at upper left edge of screen. | Shrapnel struck screen 11 feet below and 1 foot left of center; sighted at upper left edge of screen; burst on passing through screen.<br>First target, 75 feet from screen; 118 hits:<br>Balls passed through target ........... 65<br>Balls embedded in target ........... 8<br>Balls made mark ........... 7<br>Fragments passed through target ...... 18<br>Fragments embedded in target ........ 20<br>Second target, 150 feet from screen; 37 hits:<br>Balls passed through target ........... 19<br>Balls embedded in target ........... 6<br>Ball made mark ........... 1<br>Fragments passed through target ..... 3<br>Fragment embedded in target ........ 1<br>Fragments made mark ........ 7<br>Third target, 225 feet from screen; 12 hits:<br>Balls passed through target ........... 6<br>Ball embedded in target ........... 1<br>Balls made mark ........... 2<br>Fragment through target ........... 1<br>Fragments made mark ........... 2<br>Fourth target, 300 feet from screen; 2 hits:<br>Balls made mark ........... 2 |
| | | Firing conducted by Lieut. W. W. Gibson, O. D. | |

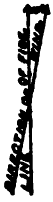
*Record of firing with 3.2-inch B. L. rifle (steel), No. 26,*

[Object of firing, to test

| Date. | | No. of fire. | Powder. | | Projectile. | | Elevation. | Wind allowance (points right). |
|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | |
| 1891. | | | | *Lbs. O.* | | *Lbs. Oz.* | ° ′ | |
| Aug. 20 | A. M. | 372 | Du Pont's I. K. H. Lot 4. Density, 1.725. Granulation, 2.571. | 3 11 | Condemned shell. | 12 11<br>11 sand.<br>13 6 | 2 25 | $\frac{3}{16}$ |
| | | 373 | | 3 11 | Condemned Hotchkiss shrapnel (lot 308), with Frankford Arsenal sensitive-point percussion fuse. | 13 3<br>2½ powder, bursting charge.<br>13 5½ | 2 29 | $\frac{2}{16}$ |
| | | 374 | | 3 11 | | 13 2¾<br>2¼ powder, bursting charge.<br>13 5 | 2 29 | $\frac{2}{16}$ |
| | | 375 | | 3 11 | | 13 3<br>3½ powder, bursting charge.<br>13 6½ | 2 29 | $\frac{3}{16}$ |
| | | 376 | | 3 11 | Condemned shell. | 12 7<br>15 sand.<br>13 6 | 2 27 | $\frac{2}{16}$ |
| | | 377 | | 3 11 | Hotchkiss shrapnel (lot 308), with sensitive-point percussion fuse. | 13 3 shrapnel and fuse.<br>3½ powder, bursting charge.<br>13 6½ | 2 25 | $\frac{3}{16}$ |
| | | 378 | | 3 11 | Condemned shell. | 12 8<br>14 sand.<br>13 6 | 2 25 | 0 |

*Watervliet Arsenal, at Sandy Hook, N. J., August 20, 1891.*

Hotchkiss shrapnel.]

| Recoil. | Wind, strength and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|
| | | Gun mounted on Buffington steel field carriage (light), No. 17; old spiral-spring brake on left wheel; bow-spring brake on right wheel. Cannon friction primers, model 1887. Telescopic sight used. | |
| *Feet.*<br>16½ | Six miles an hour.<br> | Fired to burst on passing through screen 1 mile from gun. Distance between each target, 75 feet. | Sighting shot. Struck screen 8 feet below center. |
| 11½ | | | Shrapnel burst in gun. |
| 11 | | | Shrapnel struck telegraph wires 50 feet in front of gun. No signs of burst noted near gun or at target. |
| 11 | | | Shrapnel struck screen 6 feet above center of screen and burst on passing through first target, 75 feet from screen; 28 hits:<br>Balls passed through target ............ 9<br>Balls made mark ............ 6<br>Fragments passed through target ..... 3<br>Fragments embedded in target ........ 10<br>Second target, 150 feet from screen; 68 hits:<br>Balls through target ............ 39<br>Balls embedded in target ............ 2<br>Balls made mark ............ 6<br>Fragments passed through target...... 4<br>Fragments embedded in target ........ 7<br>Fragments made mark ............ 10<br>Third target, 225 feet from screen; 34 hits:<br>Balls passed through target............ 13<br>Balls embedded in target ............ 9<br>Balls made mark ............ 5<br>Fragments embedded in target ........ 5<br>Fragments made mark ............ 2<br>Fourth target, 300 feet from screen; 22 hits:<br>Balls passed through target ............ 14<br>Balls embedded in target ............ 4<br>Balls made mark ............ 3<br>Fragment embedded in target ......... 1 |
| 12 | | Fired to burst on passing through screen 1 mile from gun. Aimed at the upper left-hand corner of screen. Distance between each target, 75 feet. | Sighting shot. Miss; struck ground about 300 feet in rear of screen. |
| 12 | | | Shrapnel broke up in gun. |
| 11½ | | | Sighting shot. Struck screen 5 feet below and 4 feet left of center. |

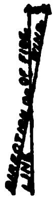
*Record of firing with 3.2-inch B. L. rifle (steel), No. 26,*

[Object of firing, to test

| Date. | | No. of fire. | Powder. | | Projectile. | | Elevation. | Wind allowance (points right). |
|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | |
| 1891. | | | | *Lbs. O.* | | *Lbs. Oz.* | ° ′ | |
| Aug. 20 | A. M. | 372 | Du Pont's I. K. H. Lot 4. Density, 1.725. Granulation, 2.571. | 3 11 | Condemned shell. | 12 11<br>11 sand.<br>13 6 | 2 25 | $\frac{2}{10}$ |
| | | 373 | | 3 11 | Condemned Hotchkiss shrapnel (lot 308), with Frankford Arsenal sensitive-point percussion fuse. | 13 3<br>2½ powder, bursting charge.<br>13 5½ | 2 29 | $\frac{2}{10}$ |
| | | 374 | | 3 11 | | 13 2½<br>2½ powder, bursting charge.<br>13 5 | 2 29 | $\frac{2}{10}$ |
| | | 375 | | 3 11 | | 13 3<br>3½ powder, bursting charge.<br>13 6½ | 2 29 | $\frac{2}{10}$ |
| | | 376 | | 3 11 | Condemned shell. | 12 7<br>15 sand.<br>13 6 | 2 27 | $\frac{2}{10}$ |
| | | 377 | | 3 11 | Hotchkiss shrapnel (lot 308), with sensitive-point percussion fuse. | 13 3 shrapnel and fuse.<br>3½ powder, bursting charge.<br>13 6½ | 2 25 | $\frac{2}{10}$ |
| | | 378 | | 3 11 | Condemned shell. | 12 8<br>14 sand.<br>13 6 | 2 25 | 0 |

*Watervliet Arsenal, at Sandy Hook, N. J., August 20, 1891.*

Hotchkiss shrapnel.]

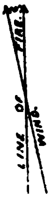
| Recoil. | Wind, strength and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|
| | | Gun mounted on Buffington steel field carriage (light), No. 17; old spiral-spring brake on left wheel; bow-spring brake on right wheel. Cannon friction primers, model 1887. Telescopic sight used. | |
| *Feet.*<br>16½ | Six miles an hour.<br><br> | Fired to burst on passing through screen 1 mile from gun. Distance between each target, 75 feet. | Sighting shot. Struck screen 8 feet below center. |
| 11½ | | | Shrapnel burst in gun. |
| 11 | | | Shrapnel struck telegraph wires 50 feet in front of gun. No signs of burst noted near gun or at target. |
| 11 | | | Shrapnel struck screen 6 feet above center of screen and burst on passing through first target, 75 feet from screen; 28 hits:<br>Balls passed through target ............ 9<br>Balls made mark ........................ 6<br>Fragments passed through target ..... 3<br>Fragments embedded in target ........ 10<br>Second target, 150 feet from screen; 68 hits:<br>Balls through target .................... 39<br>Balls embedded in target .............. 2<br>Balls made mark ........................ 6<br>Fragments passed through target...... 4<br>Fragments embedded in target ........ 7<br>Fragments made mark.................. 10<br>Third target, 225 feet from screen; 34 hits:<br>Balls passed through target............ 13<br>Balls embedded in target .............. 9<br>Balls made mark........................ 5<br>Fragments embedded in target ........ 5<br>Fragments made mark................. 2<br>Fourth target, 300 feet from screen; 22 hits:<br>Balls passed through target ........... 14<br>Balls embedded in target .............. 4<br>Balls made mark........................ 3<br>Fragment embedded in target ......... 1 |
| 12 | | Fired to burst on passing through screen 1 mile from gun. Aimed at the upper left-hand corner of screen. Distance between each target, 75 feet. | Sighting shot. Miss; struck ground about 300 feet in rear of screen. |
| 12 | | | Shrapnel broke up in gun. |
| 11½ | | | Sighting shot. Struck screen 5 feet below and 4 feet left of center. |

*Record of firing with 3.2-inch B. L. rifle (steel), No. 26, Watervliet*

[Object of firing, to test

| Date. | | No. of fire. | Powder. | | Projectile. | | Elevation. | Wind allowance (points right). |
|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | |
| 1891. | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ′ | |
| Aug. 20 | A. M. | 379 | Du Pont's I. K. H. Lot 4. Density, 1.725. Granulation, 2,571. | 3 11 | Hotchkiss shrapnel (lot 308), with Frankford Arsenal sensitive-point percussion fuse. | 13 3¼ shrapnel and fuse.<br>3¾ powder, bursting charge.<br>13 7 | 2 18 | $\frac{1}{16}$ |
| Aug. 25 | ........ | 386 | Du Pont's I. K. H. Lot 4. Density, 1.725. Granulation, 2,571. | 3 11 | Condemned shell. | 13 0<br>6 sand.<br>13 6 | 5 20 | ½ |
| | | 387 | | 3 11 | | 12 15<br>7 sand.<br>13 6 | 5 10 | 0 |
| | | 388 | | 3 11 | | 12 13<br>9 sand.<br>13 6 | 5 10 | $\frac{1}{16}$ |
| | | 389 | | 3 11 | | 12 14<br>8 sand.<br>13 6 | 5 10 | ½ |
| | | 390 | | 3 11 | | 12 14<br>8 sand.<br>13 6 | 5 07 | ½ |
| | | 391 | | 3 11 | | 12 13<br>9 sand.<br>13 6 | 5 07 | ⅛ |

*Arsenal, at Sandy Hook, N. J., from August 20 to August 25, 1891.*
**Hotchkiss shrapnel.]**

| Recoil. | Wind, strength and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|
| | | Gun mounted on Buffington steel field carriage (light), No. 17; old spiral spring-brake on left wheel; bow spring brake on right wheel. Cannon friction primers, model 1887. Telescopic sight used. | |
| *Feet.*<br>14 | Six miles an hour. | Fired to burst on passing through screen 1 mile from gun. Aimed at the upper left-hand corner of screen. Distance between each target, 75 feet. | Shrapnel struck screen 3 feet below and 6 feet to the left of center of bull's-eye.<br>First target, 75 feet from screen; 35 hits:<br>Balls through target.................... 17<br>Balls made mark........................ 2<br>Fragments passed through target...... 9<br>Fragments embedded in target ........ 6<br>Fragment made mark.................... 1<br>Second target, 150 feet from screen; 40 hits:<br>Balls passed through target ............ 18<br>Balls embedded in target............... 4<br>Balls made mark........................ 2<br>Fragments passed through target...... 3<br>Fragment embedded in target ......... 1<br>Fragments made mark................... 12<br>Third target, 225 feet from screen; 21 hits:<br>Balls passed through target............ 8<br>Balls embedded in target ............... 4<br>Balls made mark........................ 2<br>Fragments passed through target...... 4<br>Fragment embedded in target ......... 1<br>Fragments made mark................... 2<br>Fourth target, 300 feet from screen; 14 hits:<br>Balls passed through target ............ 6<br>Balls embedded in target ............... 3<br>Balls made mark........................ 2<br>Fragment passed through target....... 1<br>Fragments made mark................... 2 |
| | | Firing conducted by Lieut. W. W. Gibson, O. D., assistant proof officer.<br>Gun mounted on Buffington steel field carriage (light), No. 17; bow-spring brake on right wheel; old spiral-spring brake on left wheel. Cannon friction primers, model 1887. Telescopic sight used. | |
| 13 | Ten miles an hour. | Fired to burst on passing through screen 3,000 yards from gun. Aimed at the upper left edge of screen. Distance of first target from screen, 60 feet; distance between each target, 60 feet. | Sighting shot. Miss; high and to the right. |
| 20 | | | Sighting shot. Struck screen 5 feet below and 18 feet to the right of bull's-eye. End of trail handspike broken. |
| 14 | | | Sighting shot. Miss; high and to the right. |
| 14 |  | | Sighting shot. Struck 25 yards in front of screen and ricochetted through 4 feet below and 8 feet to the right of bull's-eye. |
| 14 | | | Sighting shot. Struck screen 6 feet below and 3 feet to the right of bull's-eye. |
| 14 | | | Sighting shot. Struck screen 4 feet below and 4 feet to the right of bull's-eye. |

*Record of firing with 3.2-inch B. L. rifle (steel), No. 26,*

[Object of firing, to test

| Date. | | No. of fire. | Powder. | | Projectile. | | Elevation. | Wind allowance (points right). |
|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | |
| 1891. | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ′ | |
| Aug. 25 | ........ | 392 | Du Pont's I. K. H. Lot 4. Density, 1.725. Granulation, 2.571. | 3 11 | Hotchkiss shrapnel (lot 308), with Frankford Arsenal sensitive-point percussion fuse. | 13 2 shrapnel and fuse.<br>3½ rifle powder, bursting charge.<br>13 5½ | 5 07 | ½ |
| | | 393 | | 3 11 | | 13 2 shrapnel and fuse.<br>3½ rifle powder, bursting charge.<br>13 5½ | 5 07 | ½ |

*Watervliet Arsenal, at Sandy Hook, N. J., August 25, 1891.*

Hotchkiss shrapnel.]

| Recoil. | Wind, strength and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|
| | | Gun mounted on Buffington steel field carriage (steel), No. 17. Bow-spring brake on right wheel; old spiral-spring brake on left wheel. Cannon friction primers, model 1887. Telescopic sight used. | |
| *Feet.*<br>14 | Ten miles an hour. | Fired to burst on passing through screen 3,000 yards from gun. Aimed at the upper left edge of screen. Distance of first target from screen, 60 feet; distance between each target, 60 feet. | Shrapnel burst on striking telegraph wires 20 yards in front of gun. |
| 14 | | | Shrapnel struck 6 feet in front of screen and burst, cutting off two lower boards of screen.<br>First target, 60 feet in front of screen; 16 hits:<br>Balls passed through target ............ 6<br>Balls embedded in target ............... 2<br>Balls made mark ........................ 0<br>Fragments passed through target ...... 2<br>Fragments embedded in target ......... 5<br>Fragment made mark..................... 1<br>Second target, 120 feet from screen; 3 hits:<br>Balls passed through ................... 2<br>Ball embedded in target ................ 1<br>Third target, 180 feet from screen; 0 hits.<br>Fourth target, 240 feet from screen; 0 hits.<br>Fifth target, 300 feet from screen; 0 hits. |
| | | Firing conducted by Lieut. W. W. Gibson, O. D., assistant proof officer. | |

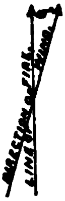
*Record of firing with 3.2-inch B. L. rifle (steel), No. 25.*

[Object of firing, to test

| Date. | | No. of fire. | Powder. | | Projectile. | | Elevation. | Wind allowance (points right). |
|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | |
| 1891. | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ' | |
| Aug. 26 | ..... | 394 | Du Pont's I. K. H. Lot 4. Density, 1.725. Granulation, 2,571. | 3 11 | Shell condemned. | 12 9<br>13 sand.<br>13 6 | 5 20 | ½ |
| | | 395 | | 3 11 | | 12 9<br>13 sand.<br>13 6 | 5 20 | 0 |
| | | 396 | | 3 11 | | 12 9<br>13 sand.<br>13 6 | 5 20 | 1/10 |
| | | 397 | | 3 11 | | 12 9<br>13 sand.<br>13 6 | 5 25 | ½ |
| | | 398 | | 3 11 | | 12 14<br>8 sand.<br>13 6 | 5 25 | ¼ |
| | | 399 | | 3 11 | | 12 13<br>9 sand.<br>13 6 | 5 25 | ½ |
| | | 400 | | 3 11 | | 12 13<br>9 sand.<br>13 6 | 5 25 | ½ |
| | | 401 | | 3 11 | | 12 12<br>10 sand.<br>13 6 | 5 25 | ¼ |
| | | 402 | | 3 11 | Hotchkiss shrapnel (lot 308), with Frankford Arsenal sensitive-point percussion fuse. | 13 3 shrapnel and fuse.<br>3½ rifle powder, bursting charge.<br>13 6½ | 5 30 | ½ |

*Watervliet Arsenal, at Sandy Hook, N. J., August 26, 1891.*

**Hotchkiss shrapnel.]**

| Recoil. | Wind, strength and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|
| | | Gun mounted on Buffington steel field carriage (light), No. 17. Bow-spring brake on left wheel; old spiral-spring brake on right wheel. Cannon friction primers, model 1887. Telescopic sight used. | |
| *Feet.*<br>13 | Fourteen miles an hour.<br> | Fired to burst on passing through screen 3,000 yards from gun. Aimed at the upper left hand corner. Distance of screen from first target, 60 feet; distance between each target, 60 feet. | Sighting shot. Struck ground 125 yards in front of screen. |
| 14 | | | Sighting shot. Struck the ground 50 yards in rear of target. |
| 14 | | | Sighting shot. Struck ground 100 yards in rear of screen. |
| 15 | | | Sighting shot. Struck ground 95 yards in rear of screen. |
| 14 | | | Sighting shot. Struck ground 20 yards in rear of screen. |
| 14 | | | Sighting shot. Struck screen 1 below and 12 to the right of bull's-eye. |
| 14 | | | Sighting shot. Struck 20 feet in front of screen, and ricochetted through 7 feet to the right and 5 feet below center of bull's-eye. |
| 14 | | | Sighting shot. Struck screen 3 feet above and 14 feet to the right of bull's-eye. |
| 14 | | | Shrapnel struck 25 feet in front of screen and burst; 24 hits on screen, as follows:<br>Balls passed through screen ....... 4<br>Balls embedded in screen .......... 4<br>Balls made mark .................... 2<br>Fragments passed through screen . 8<br>Fragments embedded in screen .... 5<br>Fragments made mark ............. 1<br>First target, 60 feet from screen; 1 hit:<br>Fragment embedded ................ 1<br>Second target, 120 feet from screen; 0 hits.<br>Third target, 180 feet from screen; 0 hits.<br>Fourth target, 240 feet from screen; 0 hits.<br>Fifth target, 300 feet from screen ; 0 hits. |
| | | Firing conducted by Lieut. W. W. Gibson, O.D., assistant proof officer. | |

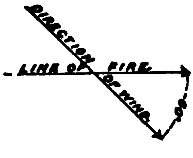
*Record of firing with 3.2-inch B. L. rifle (steel), No.*

[Object of firing, to test

| Date. | | No. of fire. | Powder. | | Projectile. | | Ele-vation. | Wind allowance (points right. |
|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | |
| 1891. | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ′ | |
| Aug. 27 | P. M. | 403 | Du Pont's I. K. H. Lot 4. Density, 1.725. Granulation, 2,571. | 3 11 | Condemned shell. | 12 13<br>9 sand.<br>13 6 | 5 27 | 2 |
| | | 404 | | 3 11 | | 12 7<br>15 sand.<br>13 6 | 6 27 | 1½ |
| | | 405 | | 3 11 | Hotchkiss shrapnel (lot 308), with Frankford Arsenal sensitive-point percussion fuse. | 13 2 shrapnel and fuse.<br>3½ rifle powder, bursting charge.<br>13 5½ | 5 27 | 1½ |
| | | 406 | | 3 11 | Condemned shell. | 13 6 including sand. | 5 27 | 1½ |
| | | 407 | | 3 11 | | 12 13<br>9 sand.<br>13 6 | 5 35 | 1½ |
| | | 408 | | 3 11 | | 12 12<br>10 sand.<br>13 6 | 5 35 | ¾ |
| | | 409 | | 3 11 | Hotchkiss shrapnel (lot 308), with Frankford Arsenal sensitive-point percussion fuse. | 13 2<br>3½ powder, bursting charge.<br>13 5½ | 5 45 | 1 |

*Watervliet Arsenal, at Sandy Hook, N. J., August 27, 1891.*

Hotchkiss shrapnel.]

| Recoil. | Wind, strength and direction. |  | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|
| *Feet.*<br>14 | Six miles an hour. | Gun mounted on Buffington steel field carriage (light), No. 17. Bow-spring brake on left wheel; old spiral-spring brake on right wheel. Cannon friction primers, model 1887. Telescopic sight used.<br>Fired to burst on passing through screen 3,000 yards from gun. Aimed at the upper left-hand corner. Distance of screen from target, 60 feet; distance between each target, 60 feet. | Sighting shot. Struck screen 4 feet below and 10 feet to the left of bull's-eye. |
| 14 |  |  | Sighting shot. Struck screen 12 feet and 13 feet to the left of bull's-eye. |
| 14 |  |  | Shrapnel struck screen 2 feet above and 6 feet to the right of bull's-eye, and above on passing through.<br>First target, 60 feet from screen; 32 hits:<br>Balls passed through target...... 14<br>Fragments passed through target 8<br>Fragments embedded in target... 9<br>Fragment made mark............. 1<br>Second target, 120 feet from screen; 43 hits:<br>Balls passed through target...... 25<br>Balls embedded in target.......... 4<br>Fragments passed through target 6<br>Fragments embedded in target... 4<br>Fragments made mark........... 4<br>Third target, 180 feet from screen; 27 hits:<br>Balls passed through target...... 16<br>Balls embedded in target.......... 7<br>Fragments passed through target. 2<br>Fragments embedded in target... 2<br>Fourth target, 240 feet from screen; 15 hits:<br>Balls passed through target...... 9<br>Balls embedded in target......... 2<br>Fragment passed through target 1<br>Fragments embedded in target... 2<br>Fragment made mark........... 1<br>Fifth target, 300 feet from screen; 6 hits:<br>Balls passed through target...... 4<br>Fragments made mark............ 2 |
| ........ |  | Fired to burst on passing through screen 3,000 yards from gun. Distance between each target, 60 feet. | Sighting shot. Struck 25 yards in front of screen. |
| ........ |  |  | Sighting shot. Miss to the left. |
| ........ |  |  | Sighting shot. Struck 5 feet above and 17 feet to the right of bull's-eye. |
| ........ |  |  | Shrapnel broke up in gun. |

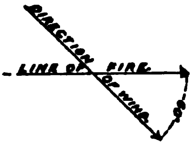
*Record of firing with 3.2-inch B. L. rifle (steel), No.*

[Object of firing, to test

| Date. | | No. of fire. | Powder. | | Projectile. | | Elevation. | Wind allowance (points right). |
|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | |
| 1891. | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ′ | |
| Aug. 27 | P. M. | 403 | Du Pont's L. K. H. Lot 4. Density, 1.725. Granulation, 2,571. | 3 11 | Condemned shell. | 12 13<br>9 sand.<br>13 6 | 5 27 | 2 |
| | | 404 | | 3 11 | | 12 7<br>15 sand.<br>13 6 | 6 27 | 1½ |
| | | 405 | | 3 11 | Hotchkiss shrapnel (lot 308), with Frankford Arsenal sensitive-point percussion fuse. | 13 2 shrapnel and fuse.<br>3½ rifle powder, bursting charge.<br>13 5½ | 5 27 | 1½ |
| | | 406 | | 3 11 | Condemned shell. | 13 6 including sand. | 5 27 | 1½ |
| | | 407 | | 3 11 | | 12 13<br>9 sand.<br>13 6 | 5 35 | 1½ |
| | | 408 | | 3 11 | | 12 12<br>10 sand.<br>13 6 | 5 35 | ¾ |
| | | 409 | | 3 11 | Hotchkiss shrapnel (lot 308), with Frankford Arsenal sensitive-point percussion fuse. | 13 2<br>3½ powder, bursting charge.<br>13 5½ | 5 45 | 1 |

*Watervliet Arsenal, at Sandy Hook, N. J., August 27, 1891.*

**Hotchkiss shrapnel.]**

| Recoil. | Wind, strength and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|
| | | Gun mounted on Buffington steel field carriage (light), No. 17. Bow-spring brake on left wheel; old spiral-spring brake on right wheel. Cannon friction primers, model 1887. Telescopic sight used. | |
| *Feet.*<br>14 | Six miles an hour. | | Sighting shot. Struck screen 4 feet below and 10 feet to the left of bull's-eye. |
| 14 | | | Sighting shot. Struck screen 12 feet and 13 feet to the left of bull's-eye. |
| 14 | | Fired to burst on passing through screen 3,000 yards from gun. Aimed at the upper left-hand corner. Distance of screen from target, 60 feet; distance between each target, 60 feet. | Shrapnel struck screen 2 feet above and 6 feet to the right of bull's-eye, and above on passing through.<br>First target, 60 feet from screen; 32 hits:<br>Balls passed through target...... 14<br>Fragments passed through target 8<br>Fragments embedded in target... 9<br>Fragment made mark............ 1<br>Second target, 120 feet from screen; 43 hits:<br>Balls passed through target...... 25<br>Balls embedded in target......... 4<br>Fragments passed through target 6<br>Fragments embedded in target... 4<br>Fragments made mark............ 4<br>Third target, 180 feet from screen; 27 hits:<br>Balls passed through target...... 16<br>Balls embedded in target......... 7<br>Fragments passed through target. 2<br>Fragments embedded in target... 2<br>Fourth target, 240 feet from screen; 15 hits:<br>Balls passed through target...... 9<br>Balls embedded in target......... 2<br>Fragment passed through target 1<br>Fragments embedded in target... 2<br>Fragment made mark............ 1<br>Fifth target, 300 feet from screen; 6 hits:<br>Balls passed through target...... 4<br>Fragments made mark............ 2 |
| ........ | | | Sighting shot. Struck 25 yards in front of screen. |
| ........ | | | Sighting shot. Miss to the left. |
| ........ | | | Sighting shot. Struck 5 feet above and 17 feet to the right of bull's-eye. |
| |  | Fired to burst on passing through screen 3,000 yards from gun. Distance between each target, 60 feet. | |
| ........ | | | Shrapnel broke up in gun. |

*Record of firing with 3.2-inch B. L. rifle (steel), No. 26, Watervlie*

[Object of firing, to test

| Date. | | No. of fire. | Powder. | | Projectile. | | Elevation. | Wind allowance (points right). |
|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | |
| 1891. | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ' | |
| Aug. 27 ... | P. M. | 410 | Du Pont's I. K. H. Lot 4. Density, 1.725. Granulation, 2,571. | 3 11 | Hotchkiss sharpnel (lot 308), with Frankford Arsenal sensitive-point percussion fuse. | 13 2<br>3¼ rifle powder, bursting charge.<br>13 5¼ | 5 45 | 1 |

*Arsenal, at Sandy Hook, N. J., August 27, 1891*—Continued.

**Hotchkiss shrapnel.]**

| Recoil. | Wind, strength and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|
| *Feet.* | | Gun mounted on Buffington steel field carriage (light), No. 17. Bow-spring brake on right wheel; old spiral-spring brake on left wheel. | |
| ........ | Six miles an hour. | Fired to burst on passing through screen 3,000 yards from gun. Telescopic sight used. Distance between each target, 60 feet. | Shrapnel struck screen 2 feet above and 6 feet to the left of bull's-eye, and burst on passing through.<br>First target, 60 feet from screen; 113 hits:<br>Balls passed through target ..... 57<br>Balls embedded in target ........ 2<br>Balls made mark ................. 10<br>Fragments passed through target 26<br>Fragment embedded in target.... 17<br>Fragment made mark............ 1<br>Second target, 120 feet from screen; 68 hits:<br>Balls passed through target..... 35<br>Balls embedded in target......... 5<br>Balls made mark................. 7<br>Fragments passed through target 9<br>Fragments embedded in target ... 3<br>Fragments made mark........... 9<br>Third target, 180 feet from screen; 24 hits:<br>Balls passed through target...... 11<br>Balls embedded in target........ 3<br>Balls made mark............... .. 2<br>Fragments passed through target 3<br>Fragments embedded in target.. 2<br>Fragments made mark.......... 3<br>Fourth target, 240 feet from screen; 10 hits:<br>Balls passed through target..... 6<br>Balls embedded in target......... 3<br>Fragment made mark............ 1<br>Fifth target, 300 feet from screen; 2 hits:<br>Ball passed through target...... 1<br>Ball embedded in target ......... 1 |

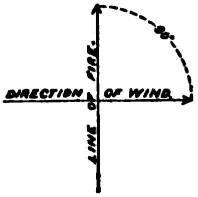
*Record of firing with 3.2-inch B. L. rifle (steel), No. 26,*

[Object of firing, to test

| Date. | | No. of fire. | Powder. | | Projectile. | | Elevation. | Wind allowance (points left). | Recoil. |
|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1891. | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ′ | | *Feet.* |
| Aug. 28 | A. M. | 411 | Du Pont's I. K. H. Lot 4. Density, 1.725. Granulation, 2,571. | 3 11 | Condemned shell. | 12 11<br>11 sand.<br>13 6 | 5 40 | $\frac{2}{10}$ | 13 |
| | | 412 | | 3 11 | | 12 11<br>11 sand.<br>13 6 | 5 40 | $\frac{2}{10}$ | 13 |
| | | 413 | | 3 11 | | 12 11<br>11 sand.<br>13 6 | 5 40 | $\frac{2}{10}$ | 14 |
| | | 414 | | 3 11 | | 12 12<br>10 sand.<br>13 6 | 5 40 | $\frac{2}{10}$ | 14 |
| | | 415 | | 3 11 | | 12 13<br>9 sand.<br>13 6 | 5 40 | 0 | 14 |
| | | 416 | | 3 11 | | 12 11<br>11 sand.<br>13 6 | 5 30 | 0 | 13 |
| | | 417 | | 3 11 | | 12 12<br>10 sand.<br>13 6 | 5 30 | 0 | 14 |
| | | 418 | | 3 11 | Hotchkiss shrapnel. Lot 308. | 13 2 shrapnel and fuse.<br>3½ powder, bursting charge<br>13 5½ | 5 40 | 0 | 13 |
| | | 419 | | 3 11 | Condemned shell. | 12 9<br>13 sand.<br>13 6 | 5 30 | ¾ | 14 |
| | | 420 | | 3 11 | | 12 10<br>12 sand.<br>13 6 | 5 20 | 1½ | 14 |
| | | 421 | | 3 11 | | 13 0<br>6 sand.<br>13 6 | 5 10 | $\frac{2}{10}$ | 13 |
| | | 422 | | 3 11 | | 12 15<br>7 sand.<br>13 6 | 5 15 | $\frac{2}{10}$ | 12 |
| | | 423 | | 3 11 | | 12 13<br>9 sand.<br>13 6 | 5 20 | 0 | 13 |

*Watervliet Arsenal, at Sandy Hook, N. J., August 28, 1891.*

Hotchkiss shrapnel.]

| Wind, strength and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|
| | Gun mounted on Buffington steel field carriage (light), No. 17. Bow-spring brake on right wheel; old spiral-spring brake on left wheel. Cannon friction primers, model 1887. Telescopic sight used. | |
| Six miles an hour.<br><br> | Fired to burst on passing through screen 3,000 yds. from gun. Aimed at the upper left-hand corner. Distance of screen from target, 60 feet; distance between targets, 60 feet. | Sighting shot. Struck the ground 25 yards in rear of screen. |
| | | Sighting shot. Struck the ground 75 yards in rear and 25 feet to the left of screen. |
| | | Sighting shot. Struck the ground 100 yards in rear and 25 feet to the left of screen. |
| | | Sighting shot. Struck the ground 25 yards in rear and 14 feet to the right of screen. |
| | | Sighting shot. Struck screen 14 feet above and 8 feet to the right of bull's-eye. |
| | | Sighting shot. Struck screen 3 feet above and 13 feet to the right of bull's-eye. |
| | | Sighting shot. Struck screen 8 feet above and 12 feet to the right of bull's-eye. |
| | | Traces of blowholes on head of shrapnel. Miss; struck the ground 50 yards in rear of screen. |
| | | Sighting shot. Struck the ground 30 yards in rear of screen. |
| | | Sighting shot. Struck the ground 50 yards in rear of screen. |
| | Fired at screen 3,000 yards from gun. Aimed at the upper left-hand corner. | Sighting shot. Struck the ground 50 yards in front of screen. |
| | | Sighting shot. Struck the ground 25 yards in front of screen. |
| | | Sighting shot. Struck the ground 10 feet in front of screen. |

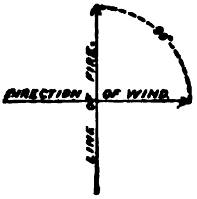
*Record of firing with 3.2-inch B. L. rifle (steel), No. 26, Watervliet*

[Object of firing, to test

| Date. | | No. of fire. | Powder. | | Projectile. | | Elevation. | Wind allowance, points left. | Recoil. |
|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1891. | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ′ | | *Feet.* |
| Aug. 28 | P. M. | 424 | Du Pont's I. K. H. Lot 4. Density, 1.725. Granulation, 2,571. | 3 11 | Condemned shell. | 12 14<br>8 sand.<br>13 6 | 5 25 | 0 | 14 |
| | | 425 | | 3 11 | | 12 12<br>10 sand.<br>13 6 | 5 30 | 0 | 14 |
| | | 426 | | 3 11 | | 13 0<br>6 sand.<br>13 6 | 5 30 | ¾ | 14 |
| | | 427 | | 3 11 | | 13 0<br>6 sand.<br>13 6 | 5 35 | 1½ | 14 |
| | | 428 | | 3 11 | | 12 14<br>8 sand.<br>13 6 | 5 35 | ¾ | 14 |
| | | 429 | | 3 11 | | 12 12<br>10 sand.<br>13 6 | 5 30 | 1 | 14 |
| | | 430 | | 3 11 | | 12 13<br>9 sand.<br>13 6 | 5 35 | $\frac{3}{16}$ | 14 |
| | | 431 | | 3 11 | Hotchkiss shrapnel (lot 308), with Frankford Arsenal sensitive-point percussion fuse. | 13 1 shrapnel and fuse.<br>3½ rifle powder, bursting charge.<br>13 4½ | 5 35 | ½ | ........ |

*Arsenal, at Sandy Hook, N. J., August 28, 1891*—Continued.

Hotchkiss shrapnel.]

| Wind, strength and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|
| | Gun mounted on Buffington steel field carriage (light), No. 17. Bow-spring brake on right wheel; old spiral-spring brake on left wheel. Cannon friction primers, model 1887. Telescopic sight used. | |
| Six miles an hour.<br><br> | Fired at screen 3,000 yards from gun. Aimed at the upper left-hand corner. | Sighting shot. Struck the ground 25 yards in front of screen. |
| | | Sighting shot. Struck the ground 20 yards in front of screen. |
| | | Sighting shot. Struck the ground 5 yards in front of screen. |
| | | Sighting shot. Struck the ground 20 yards in rear. |
| | | Sighting shot. Struck the ground 40 yards in rear. |
| | | Sighting shot. Struck screen 8 feet to the left and 2 feet above bull's-eye. |
| | | Sighting shot. Struck screen 2 feet to the left and 12 feet above bull's-eye. |
| | Fired to burst on passing through screen 3,000 yards from gun. Aimed at the upper left-hand corner of screen. Distance between each target, 60 feet. | Shrapnel struck screen 12 feet above and 2 feet to the left of bull's-eye, and burst on passing through.<br>First target, 60 feet from screen; 3 hits, as follows:<br>Ball passed through target......... 1<br>Ball embedded in target ........... 1<br>Fragment made mark.............. 1<br>Second target, 120 feet from screen; 50 hits:<br>Balls passed through target........ 27<br>Balls embedded in target ........... 4<br>Ball made mark.................... 1<br>Fragments passed through target.. 6<br>Fragments embedded in target .... 5<br>Fragments made mark............. 7<br>Third target, 180 feet from screen; 40 hits:<br>Balls passed through target........ 21<br>Balls embedded in target .......... 6<br>Ball made mark.................... 1<br>Fragments passed through target.. 2<br>Fragments embedded in target .... 5<br>Fragments made mark............. 5<br>Fourth target, 240 feet from screen; 41 hits:<br>Balls passed through target........ 27<br>Balls embedded in target .......... 8<br>Balls made mark.................... 2<br>Fragment passed through target... 1<br>Fragment embedded in target ..... 1<br>Fragments made mark............. 2<br>Fifth target, 300 feet from screen; 46 hits:<br>Balls passed through target........ 26<br>Balls embedded in target .......... 8<br>Fragments passed through target.. 4<br>Fragments embedded in target .... 4<br>Fragments made mark............. 4 |
| | Firing conducted by Lieut. W. W. Gibson, O. D., assistant proof officer. | |

*Record of firing with 3.2-inch B. L. rifle (steel), No. 26,*

[Object of firing, to test

| Date. | | No. of fire. | Powder. | | Projectile. | | Elevation. | Wind allowance (points left). |
|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | |
| | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ′ | |
| 1891.<br>Aug. 31 | P. M. | 432 | Du Pont's I. K. H. Lot 4. Density, 1.725. Granulation, 2.571. | 3 11 | Condemned shell. | 12 15<br>7 sand.<br>13 6 | 5 30 | ¼ |
| | | 433 | | 3 11 | | 12 14<br>8 sand.<br>13 6 | 5 30 | ¾ |
| | | 434 | | 3 11 | | 12 14<br>8 sand.<br>13 6 | 5 25 | ½ |
| | | 435 | | 3 11 | | 12 14<br>8 sand.<br>13 6 | 5 27 | 1 |
| | | 436 | | 3 11 | | 12 12<br>10 sand.<br>13 6 | 5 25 | 1½ |
| | | 437 | | 3 11 | | 13 0<br>6 sand.<br>13 6 | 5 25 | 1¾ |
| | | 438 | | 3 11 | Hotchkiss shrapnel (lot 308), with Frankford Arsenal sensitive point percussion fuse. | 13 1<br>3½ rifle powder, bursting charge.<br>13 4½ | 5 30 | 1¼ |
| | | 439 | | 3 11 | Condemned shell. | 13 0<br>6 sand.<br>13 6 | 5 27 | 1¾ |

*Watervliet Arsenal, at Sandy Hook, N. J., August 31, 1891.*

Hotchkiss shrapnel.]

| Recoil. | Wind, strength and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|
| *Feet.*<br>14 | ............ | Gun mounted on Buffington steel field carriage (light), No. 17. Bow-spring brake on left wheel; old spiral-spring brake on right wheel. Cannon friction primers, model 1887. Telescopic sight used. | Sighting shot. Miss; high, and to the right. |
| 14 | ............ | | Sighting shot. Miss; high, and to the right. |
| 13½ | ............ | | Sighting shot. Miss; high, and to the right. |
| 14 | ............ | | Sighting shot. Miss; high, and to the right |
| 14 | ............ | | Sighting shot. Struck screen 10 feet above and 2 feet to the left of bull's-eye. |
| 14 | ............ | | Sighting shot. Struck screen 2 feet above and 3 feet to the right of bull's-eye. |
| 14 | ............ | Fired to burst on passing through screen 3,000 yards from gun. Aimed at the upper left-hand corner. Distance between each target, 60 feet. | Shrapnel struck screen 2 feet below and 2 feet to the left of bull's-eye, and burst.<br>First target, 60 feet from screen; 88 hits:<br>Balls through target.............. 54<br>Ball embedded in target ............ 1<br>Fragments passed through target.. 19<br>Fragments embedded in target .... 14<br>Second target, 120 feet from screen; 68 hits:<br>Balls passed through target........ 37<br>Balls embedded in target .......... 7<br>Balls made mark.................... 3<br>Fragments passed through target.. 12<br>Fragments embedded in target..... 3<br>Fragments made mark............. 6<br>Third target, 180 feet from screen; 55 hits:<br>Balls passed through target........ 31<br>Balls embedded in target .......... 5<br>Balls made mark.................... 7<br>Fragments passed through target.. 3<br>Fragments embedded in target .... 5<br>Fragments made mark............. 4<br>Fourth target, 240 feet from screen; 20 hits:<br>Balls passed through target........ 11<br>Balls embedded in target .......... 4<br>Fragment embedded in target ..... 4<br>Fragments made mark............. 4<br>Fifth target, 300 feet from screen; 7 hits:<br>Balls passed through target........ 1<br>Balls made mark.................... 2<br>Fragment made mark.............. 1 |
| 14 | ............ | Fired to burst on passing through screen 3,000 yards from gun. Aimed at the upper left-hand corner of screen. Distance between each target, 60 feet. | Sighting shot. Struck screen 2 feet below and 2 feet to the right of bull's-eye. |

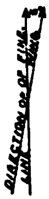
*Record of firing with 3.2-inch B. L. rifle (steel), No. 26, Watervliet*

[Object of firing, to test

| Date. | | No. of fire. | Powder. | | Projectile. | | Elevation. | Wind allowance (points left). |
|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | |
| 1891. | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ′ | |
| Aug. 31 | P. M. | 440 | Du Pont's I. K. H. Lot 4. Density, 1.725. Granulation, 2,571. | 3 11 | Hotchkiss shrapnel (lot 308), with Frankford Arsenal sensitive-point percussion fuse. | 13 1½<br>3½ powder, bursting charge.<br>13 5 | 5 30 | 1¾ |
| | | 441 | | 3 11 | | 13 3<br>3 rifle powder, bursting charge.<br>13 6 | 5 29 | 1¾ |
| Sept. 1 | A. M. | 442 | Du Pont's I. K. H. Lot 4. Density, 1.725. Granulation, 2,571. | 3 11 | Condemned shell. | 12 13<br>9 sand.<br>13 6 | 2 10 | ½ |
| | | 443 | | 3 11 | | 12 13<br>9 sand.<br>13 6 | 2 10 | ¾ |
| | | 444 | | 3 11 | Hotchkiss shrapnel (lot 308), with Frankford Arsenal sensitive-point percussion fuse. | 13 3<br>3½ rifle powder, bursting charge.<br>13 6½ | 2 15 | ½ |
| | | 445 | | 3 11 | | 13 2<br>3½ rifle powder, bursting charge.<br>13 5½ | 2 17 | ½ |

*Arsenal, at Sandy Hook, N. J., from August 31 to September 1, 1891.*

Hotchkiss shrapnel.]

| Recoil. | Wind, strength and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|
| | | Gun mounted on Buffington steel field carriage (light), No. 17. Bow-spring brake on left wheel; old spiral-spring brake on right wheel. Cannon friction primers, model 1887. Telescopic sight used. | |
| *Feet.*<br>14 | ............ | Fired to burst on passing through screen 3,000 yards from gun. Aimed at the upper left-hand corner of screen. Distance between each target, 60 feet. | Shrapnel burst in gun. |
| 14 | ............ | | Shrapnel struck 18 feet below center of screen, and burst on passing through.<br>First target, 60 feet from screen; 47 hits:<br>Balls passed through target........ 15<br>Balls embedded in target .......... 2<br>Balls made mark.................... 3<br>Fragments passed through target.. 6<br>Fragments embedded in target..... 9<br>Fragments made mark............. 12<br>Second target, 120 feet from screen; 15 hits:<br>Balls passed through target........ 7<br>Balls embedded in target .......... 2<br>Fragments passed through target.. 2<br>Fragments made mark............. 4<br>Third target, 180 feet from screen; 9 hits:<br>Balls passed through target........ 3<br>Fragment passed through target... 1<br>Fragments embedded in target .... 2<br>Fragments made mark.............. 3<br>Fourth target, 240 feet from screen; 9 hits:<br>Balls passed through target........ 3<br>Ball embedded in target ........... 1<br>Fragments passed through target.. 4<br>Fragment embedded in target ..... 1<br>Fifth target, 300 feet from screen; 6 hits:<br>Balls passed through target........ 1<br>Ball made mark...................... 1<br>Fragment passed through target... 1<br>Fragment embedded in target ..... 3 |
| | | Firing conducted by Lieut. W. W. Gibson, O. D., assistant proof officer.<br>Gun mounted on Buffington steel field carriage (light), No. 17. Bow-spring brake on left wheel; old spiral-spring brake on right wheel. Cannon friction primers, model 1887. Telescopic sight used. | |
| 14 | Eight miles an hour.<br> | Fired to burst on striking ground in front of 1-mile screen. | Sighting shot. |
| 14 | | | Sighting shot. |
| 14 | | | Shrapnel struck the ground in front of screen; did not burst. |
| 14 | | | Shrapnel struck the ground 70 yards in front of screen and burst; 63 hits on screen, as follows:<br>Balls passed through screen ....... 50<br>Balls embedded in screen ..........<br>Fragments passed through screen.. 9<br>Fragments embedded in screen.... 2 |
| - | | Firing conducted by Lieut. W. W. Gibson, O. D., assistant proof officer. | |

*Record of firing with 3.2-inch B. L. rifle (steel), No. [illegible]*

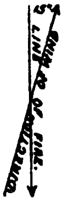
[Object of firing, to determine charge to give remaining

| Date. | | No. of fire. | Powder. | | Projectile. | | Elevation. | Instrumental velocity, 100 feet from muzzle. | Pressure per square inch of bore. |
|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1891. | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ' | *Feet.* | *Pounds.* |
| Sept. 12 | A. M. | 446 | Du Pont's I. K. H. Lot 4. Density, 1,725. Granulation, 2,571. | 1 0 | Condemned shell. | *13 5 | 0 30 | 786<br>786<br>786 | No. 3, less than 9,000. |
| | | 447 | | 0 14 | | *13 5 | 0 30 | 725<br>725<br>Lost. | No. 3, 6,000 |
| | | 448 | | 0 15 | | *13 5 | 0 30 | 762<br>770<br>777 | No. 3, 6,300 |
| | | 449 | | 0 15 | | *13 5 | 0 30 | Lost | No. 3, 6,000 |
| | | 450 | | 0 15 | | *13 5 | 0 30 | Lost.<br>50+$\frac{100}{2}$ | No. 3, 6,200 |
| | | 451 | | 0 15 | | *13 5 | 0 30 | Velocity, 75 feet from muzzle.<br>Lost.<br>750<br>750<br>50+$\frac{50}{2}$ | No. 3, 5,800 |

*Including sand.

*Watervliet Arsenal, at Sandy Hook, N. J., September 12, 1891.*

**velocity at 4,000-yards range for shrapnel experiment.]**

| Wind, strength and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|
| | Gun mounted on Buffington steel field carriage (light), No. 17. Old spiral-spring brakes. Cannon friction primers, model 1887. | |
| 4 miles an hour. | Fired into field butt | Copper cylinders of 9,000 pounds initial compression and tables of 1890. |
|  | Uncompressed copper cylinders and tables of 1890 used in rounds 447 to 451, inclusive.<br>Firing conducted by Lieut. W. W. Gibson, O. D., assistant proof officer. | |

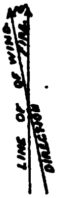
*Record of firing with 3.2-inch B. L. rifle (steel), No. 26,*

[Object of firing, to test

| Date. | No. of fire. | Powder. | | Projectile. | | Elevation. | Recoil. |
|---|---|---|---|---|---|---|---|
| | | Kind. | Weight. | Kind. | Weight. | | |
| 1891. | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ' | *Feet.* |
| Sept. 14 | 452 | Du Pont's I. K. H. Lot 4. Density, 1,725. Granulation, 2,571. | 0 15 | Hotchkiss shrapnel (lot 308), with Frankford Arsenal sensitive-point percussion fuse. | 13 2<br>3 powder, bursting charge.<br>13 5 | 4 00 | 4 |
| | 453 | | 0 45 | | 13 3<br>3 powder, bursting charge.<br>13 6 | 3 30 | 4 |
| | 454 | | 0 15 | | 13 2<br>3 powder, bursting charge.<br>13 5 | 2 00 | 4 |

*Watervliet Arsenal, at Sandy Hook, N. J., September 14, 1891.*

Hotchkiss shrapnel.]

| Wind, strength and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|
| | Gun mounted on Buffington steel field carriage (light), No. 17, with old spiral-spring brakes. Cannon friction primers, model 1887. | |
| Eight miles an hour.<br><br> | Fired to burst on passing through screen 25 yards in front of target. Gun 75 feet from screen. Height of target increased from 11 feet to 16 feet and thickness increased from 1 to 2 inches. Size of target, 16 feet by 52 feet. | Struck screen 10 feet above ground and 2 feet left of center and burst on passing through.<br>Target 25 yards from screen; 183 hits:<br>Balls passed through target.......... 61<br>Balls embedded in target............ 64<br>Balls made mark...................... 4<br>Fragments passed through target.... 11<br>Fragments embedded in target....... 33<br>Fragments made mark ................ 10<br><br>Struck screen 6 feet above ground and 2 feet left of center and burst on passing through.<br>Target 25 yards from screen; 229 hits:<br>Balls passed through target.......... 24<br>Balls embedded in target............ 121<br>Balls made mark...................... 4<br>Fragments passed through target.... 13<br>Fragments embedded in target....... 57<br>Fragments made mark ................ 10<br><br>Good size blowholes found near end of shrapnel.<br>Struck screen 5 feet above ground and 4 feet left of center and burst on passing through.<br>Target 25 yards from screen; 233 hits:<br>Balls passed through target.......... 20<br>Balls embedded in target............ 131<br>Fragments passed through target.... 9<br>Fragments embedded in target....... 60<br>Fragments made mark ................ 13 |
| | Firing conducted by Lieut. W. W. Gibson, O. D., assistant proof officer. | |

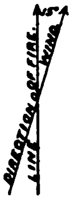
*Record of firing with 3.2-inch B. L. rifle (steel), No. 2*

[Object of fire, to test

| Date. | | No. of fire. | Powder. | | Projectile. | | Elevation. | Wind allowance (points left) |
|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | |
| 1891. | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ′ | |
| Sept. 18 | A. M. | 457 | Du Pont's I. K. H. Lot 4. Density, 1.725. Granulation, 2,571. | 3 11 | Condemned shell. | 12 15<br>7 sand.<br>13 6 | 2 10 | ........ |
| | | 458 | | 3 11 | | 12 14<br>8 sand.<br>13 6 | 2 15 | ½ |
| | | 459 | | 3 11 | Hotchkiss shrapnel, with Frankford Arsenal sensitive-point percussion fuse. | 13 2<br>3 powder, bursting charge.<br>13 5 | 2 15 | ½ |
| | | 460 | | 3 11 | | 13 2<br>3 powder, bursting charge.<br>13 5 | 2 15 | ½ |
| | | 461 | | 3 11 | | 13 2<br>3 powder, bursting charge.<br>13 5 | 2 10 | ½ |
| | | 462 | | 3 11 | Condemned shell. | 13 0<br>6 sand.<br>13 6 | 2 10 | ½ |
| | | 463 | | 3 11 | Hotchkiss shrapnel, with Frankford Arsenal sensitive-point percussion fuse. | 13 2<br>3 powder, bursting charge.<br>13 5 | 2 10 | ½ |
| | | 464 | | 3 11 | | 13 2<br>3 powder, bursting charge.<br>13 5 | 2 10 | ½ |

*Watervliet Arsenal, at Sandy Hook, N. J., September 18, 1891.*

**Hotchkiss shrapnel.]**

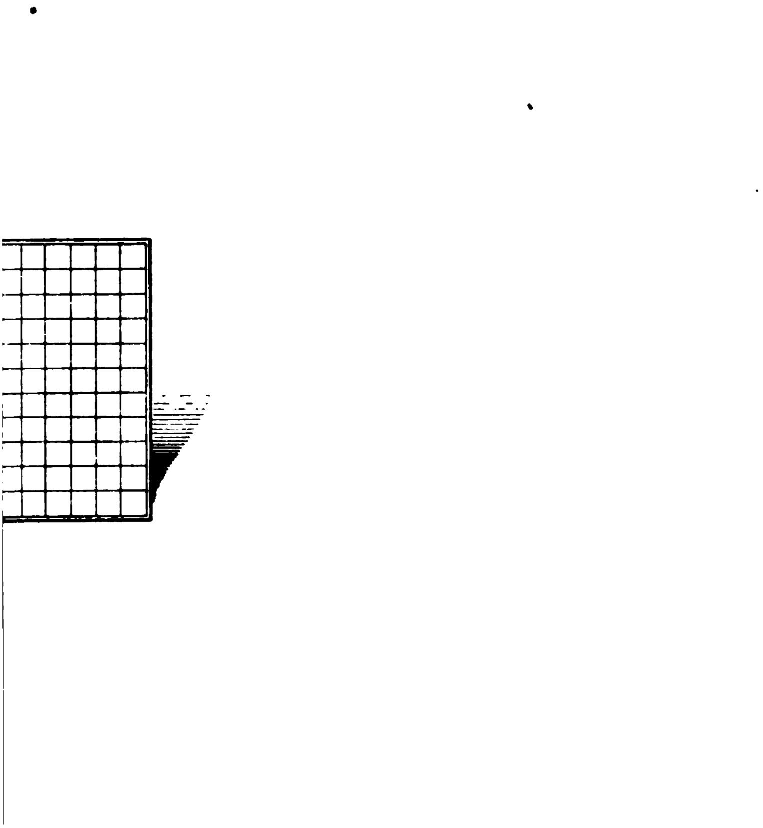
| Recoil. | Wind, strength and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|
| | | Gun mounted on Buffington steel field carriage (light), No. 17. Bow-spring brake on right wheel; old spiral-spring brake on left wheel. Cannon friction primers, model 1887. | |
| *Feet.*<br>9 | Six miles an hour. | Fired to burst on striking the ground in front of 1-mile target. | Sighting shot. Struck the ground 200 feet in front of target and 4 feet to the right. |
| 11 | | | Sighting shot. Struck the ground 25 feet in front of target and 3 feet to the left. |
| 10 | | | Shrapnel struck the ground 70 feet in front of target; ricochetted through; did not burst. |
| 9 | | | Shrapnel struck the ground 15 feet in rear of target and 4 feet to the left, and burst. |
| 10 | | | Shrapnel broke up in gun. |
| 11 | | | Sighting shot. Struck the ground 100 feet in front of target; ricochetted through, 15 feet to the left and 2 feet above center of target; shot away iron line pole 130 feet in front and a little to the right of target. |
| 11 | | | Shrapnel broke up in gun. |
| 11 |  | | Many blowholes found in point of shrapnel; struck same iron line pole as sighting shot (round 462), 2 feet 4 inches from the ground, nearly cutting away pole, and burst.<br>Balls passed through target .... 89<br>Balls embedded in target ....... 7<br>Balls made mark ................ 2<br>Fragments passed through target 20<br>Fragments embedded in target .. 13<br>Fragments made mark .......... 9<br>Total ...................... 140 |
| | | Firing conducted by Lieut. W. W. Gibson, O. D., assistant proof officer. | |

*Record of firing with 3.2-inch B. L. rifle (steel), No. 26,*

[Object of fire, to test

| Date. | | No. of fire. | Powder. Kind. | Powder. Weight. | Projectile. Kind. | Projectile. Weight. | Elevation. | Wind allowance (points left) |
|---|---|---|---|---|---|---|---|---|
| 1891. | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ′ | |
| Sept. 18 | A. M. | 457 | Du Pont's I. K. H. Lot 4. Density, 1.725. Granulation, 2,571. | 3 11 | Condemned shell. | 12 15<br>7 sand.<br>13 6 | 2 10 | ........ |
| | | 458 | | 3 11 | | 12 14<br>8 sand.<br>13 6 | 2 15 | ¼ |
| | | 459 | | 3 11 | Hotchkiss shrapnel, with Frankford Arsenal sensitive-point percussion fuse. | 13 2<br>3 powder, bursting charge.<br>13 5 | 2 15 | ¾ |
| | | 460 | | 3 11 | | 13 2<br>3 powder, bursting charge.<br>13 5 | 2 15 | ¼ |
| | | 461 | | 3 11 | | 13 2<br>3 powder, bursting charge.<br>13 5 | 2 10 | ½ |
| | | 462 | | 3 11 | Condemned shell. | 13 0<br>6 sand.<br>13 6 | 2 10 | ¾ |
| | | 463 | | 3 11 | Hotchkiss shrapnel, with Frankford Arsenal sensitive-point percussion fuse. | 13 2<br>3 powder. bursting charge.<br>13 5 | 2 10 | ¼ |
| | | 464 | | 3 11 | | 13 2<br>3 powder, bursting charge.<br>13 5 | 2 10 | ¼ |

PLATE I.



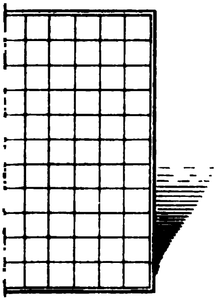
ET RECORD OF 3.2 B.L.RIFLE (STEEL) Nº 26

TH HOTCHKISS SHRAPNEL Nº 1.

TARGET 1000 YDS. FROM GUN.

Appendix 36, 1891.

PLATE I.

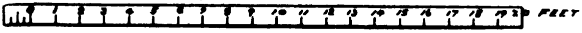


GET RECORD OF 3.2 B.L. RIFLE (STEEL) No. 26

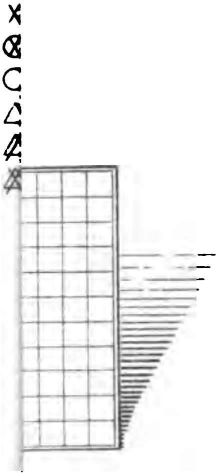
TH HOTCHKISS SHRAPNEL No. 1.

TARGET 1000 YDS. FROM GUN.

SCALE



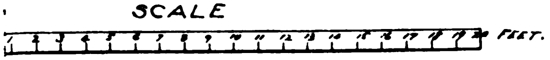
Appendix 36, 1891.

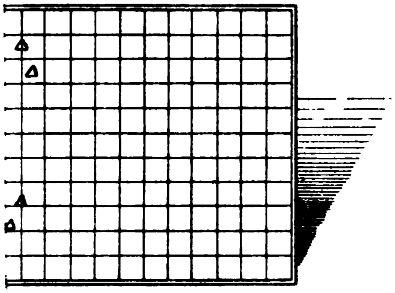


RECORD OF 3.2 B.L. RIFLE (STEEL) Nº 26

HOTCHKISS SHRAPNEL Nº 3.

GET 1000 YDS. FROM GUN.

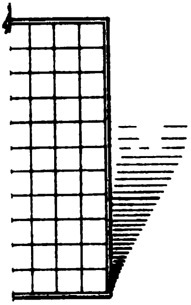




TARGET RECORD OF 3.2 B.L. RIFLE (STEEL) No. 26
WITH HOTCHKISS SHRAPNEL No. 4
TARGET 1000 YDS. FROM GUN.

SCALE

PLATE IV.



RECORD OF 3.2 B.L. RIFLE (STEEL) Nº 26

HOTCHKISS SHRAPNEL Nº 5

GET 1000 YDS. FROM GUN.

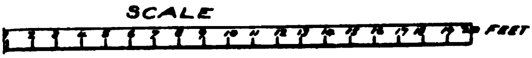
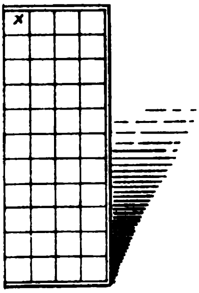
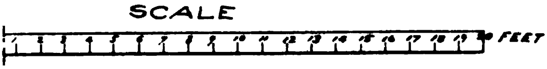


PLATE V.

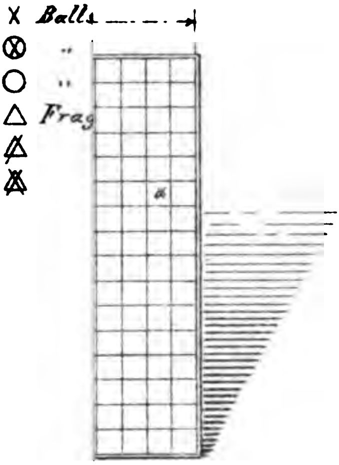


RECORD OF 3.2 B.L. RIFLE (STEEL) N°26
HOTCHKISS SHRAPNEL No. 6
RGET 1000 YDS. FROM GUN.



Ord

PLATE VI.

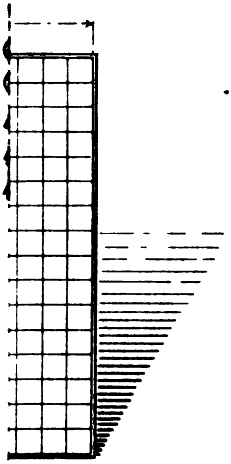


ECORD OF 3.2 B.L.RIFLE (STEEL) Nº 26

OTCHKISS SHRAPNEL Nº 1.

ET 50 YARDS FROM GUN.

PLATE VII.



RD OF 3.2 B.L.RIFLE (STEEL) Nº 26

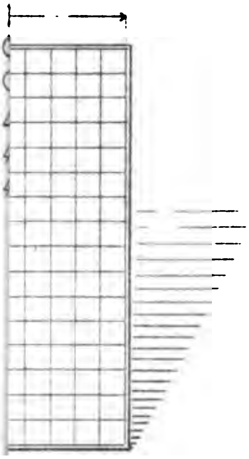
CHKISS SHRAPNEL Nº 2.

50 YARDS FROM GUN.

Or

Appendix 36, 1891.

PLATE VIII.

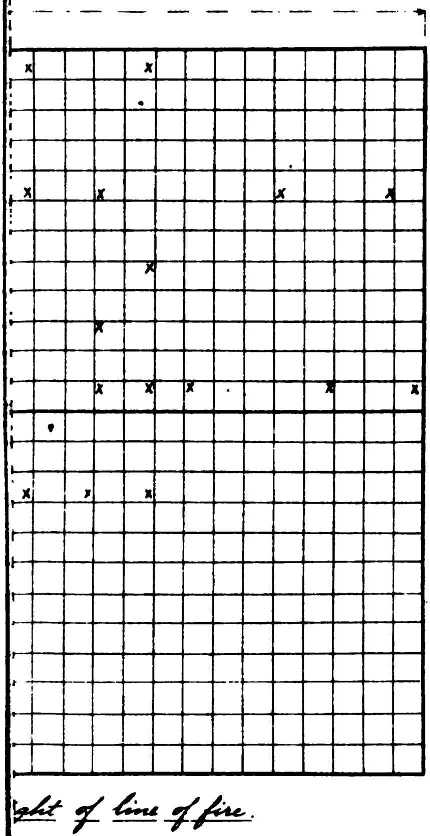


ORD OF 3.2 B.L. RIFLE (STEEL) Nº 26

TCHKISS SHRAPNEL Nº 3.

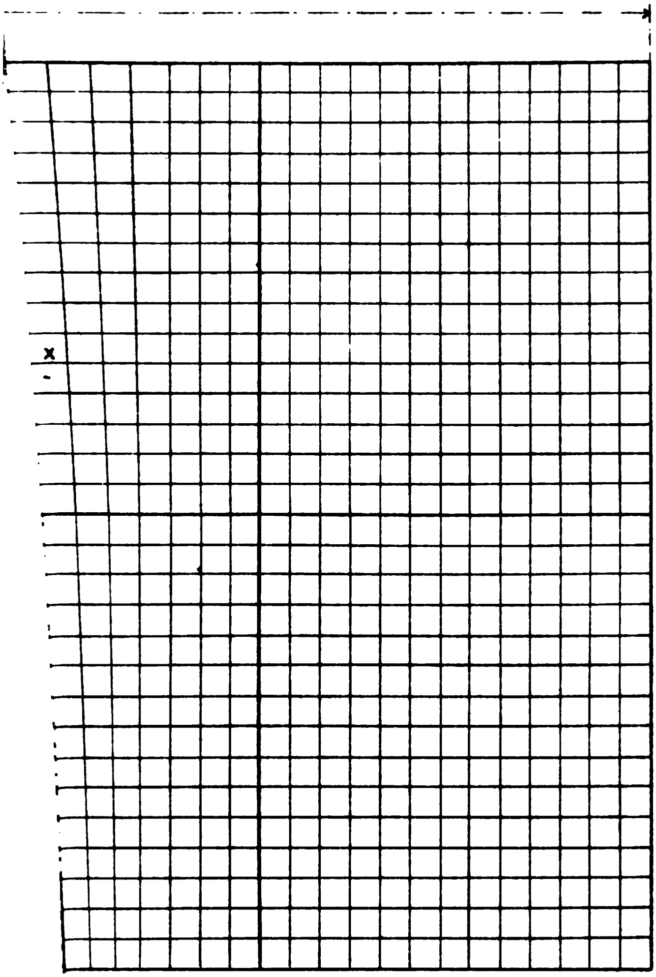
50 YARDS FROM GUN.

PLATE IX.

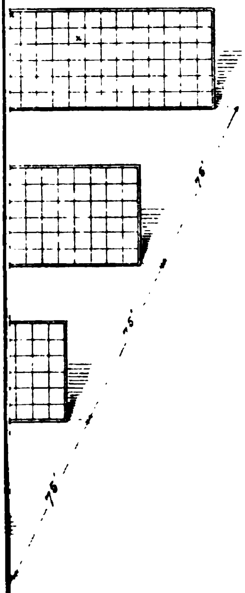


RGET RECORD OF 3.2 B.L.RIFLE (STEEL) Nº 26
WITH HOTCHKISS SHRAPNEL Nº 2.
TARGET 1760 YARDS FROM GUN.

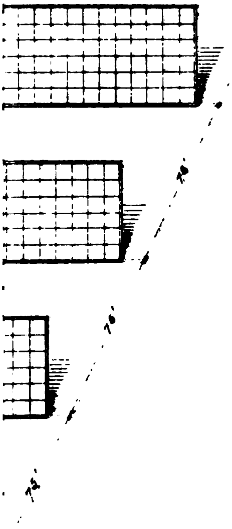
PLATE X.



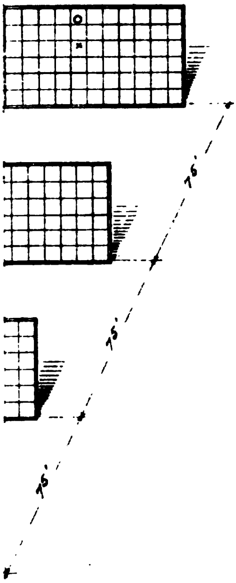
RGET RECORD OF 3.2 B.L.RIFLE (STEEL) No 26
WITH HOTCHKISS SHRAPNEL No 7.
TARGET 1760 YARDS FROM GUN.



TARGET RECORD OF 3.2 B.L. RIFLE (STEEL) No. 26
WITH HOTCHKISS SHRAPNEL No. 1.
TARGET 1760 YARDS FROM GUN.

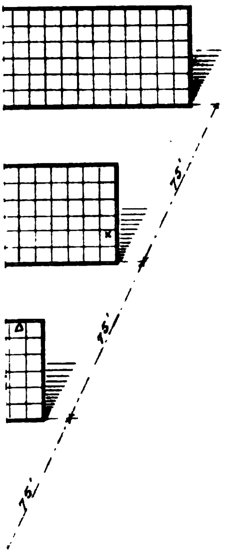


TARGET RECORD OF 3.2 B.L. RIFLE (STEEL) No. 26
WITH HOTCHKISS SHRAPNEL No. 2.
TARGET 1760 YARDS FROM GUN.



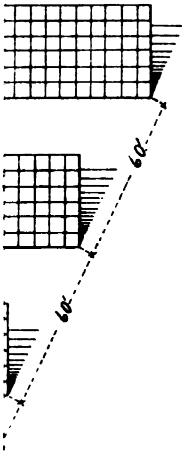
TARGET RECORD OF 3.2 B.L. RIFLE (STEEL) No. 26
WITH HOTCHKISS SHRAPNEL No. 5.
TARGET 1760 YARDS FROM GUN.

**PLATE XIV.**

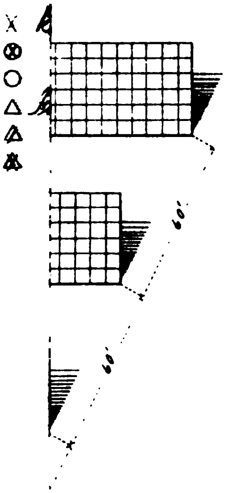


TARGET RECORD OF 3.2 B.L. RIFLE (STEEL) Nº 26
WITH HOTCHKISS SHRAPNEL Nº 7.
TARGET 1760 YARDS FROM GUN.

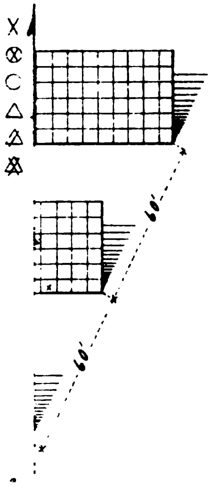
PLATE XV.



Target record of 3.2 B.L. Rifle (Steel) No. 26
with
Hotchkiss Shrapnel No. 2
Target 3000 yds from Gun

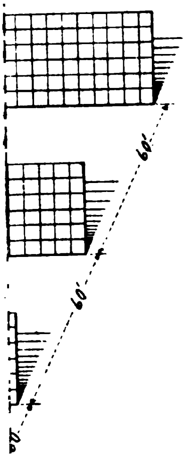


Target record of 32 B.L. Rifle (Steel) No 26
with
Hotchkiss Shrapnel No 3
Target 3000 yds from Gun



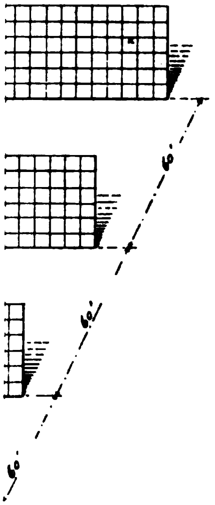
Target record of 32 B.L. Rifle (Steel) No 26
with Hotchkiss Shrapnel No 4
Target 3000 yds from Gun.

## PLATE XVIII



Target record of 3.2 B.L. Rifle (Steel) No. 26
with
Hotchkiss Shrapnel No 6
Target 3000 yds. from Gun

PLATE XIX.



Target Record of 3.2 B.L. Rifle (Steel) No. 26
with Hotchkiss Shrapnel. No. 8.
Target 3000 yards from Gun.

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1, Wat*

[Object of firing, to test

| Date. | | No. of fire. | Powder. | | | Projectile. | | | | Travel of shot in bore. | Elevation. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | | Kind. | Weight. | | | | | |
| | | | | *Lbs.* | *Oz.* | | *Lbs.* | *Oz.* | | *Inches.* | ° | ' |
| 1889. | | | | | | | | | | | | |
| Dec. 19 | P. M ...... | 1 | Du Pont's I. K. F. Density, 1.725. Granulation, 2,016. | 0 | 8 | Shell (banded), experimental. Lot 249. | 18 | 10 | | 16.17 | 0 | 40 |
| | | | | | | | 1 | 2 | sand. | | | |
| | | | | | | | 20 | 0 | | | | |
| | | 2 | | 0 | 12 | | 19 | 0 | | 16.17 | 0 | 40 |
| | | | | | | | 1 | 0 | sand. | | | |
| | | | | | | | 20 | 0 | | | | |
| | | 3 | | 0 | 14 | | 19 | 3 | | 16.16 | 0 | 40 |
| | | | | | | | | 13 | sand. | | | |
| | | | | | | | 20 | 0 | | | | |
| | | 4 | | 1 | 0 | | 19 | 2 | | 16.17 | 0 | 40 |
| | | | | | | | | 14 | sand. | | | |
| | | | | | | | 20 | 0 | | | | |

[Object o

| Date. | | No. of fire. | Powder kind. | Powder weight, Lbs. | Oz. | Projectile kind. | Projectile weight, Lbs. | Oz. | | Travel of shot in bore. | Elevation ° | ' |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dec. 20 | A. M ...... | 5 | Du Pont's mortar powder. Density, 1.750. | 0 | 1[illegible] | Shell (banded), experimental. Lot 249 | 19 | 1 | | 16.16 | 0 | 50 |
| | | | | | | | | 15 | sand. | | | |
| | | | | | | | 20 | 0 | | | | |
| | | 6 | | 0 | 14 | | 19 | 4 | | 16.17 | 0 | 50 |
| | | | | | | | | 12 | sand. | | | |
| | | | | | | | 20 | 0 | | | | |
| | | 7 | | 1 | 0 | | 19 | 0 | | 16.16 | 0 | 50 |
| | | | | | | | 1 | 0 | sand. | | | |
| | | | | | | | 20 | 0 | | | | |
| | | 8 | | 0 | 14 | | 19 | 4 | | 16.15 | 0 | 50 |
| | | | | | | | | 12 | sand. | | | |
| | | | | | | | 20 | 0 | | | | |

*Arsenal, at Sandy Hook, N. J., from December 19 to December 20, 1889.*

**and determine a suitable powder.]**

| Pressure per square inch of bore. | Recoil. | | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|---|
| | | | Mortar mounted on new experimental carriage made at Watervliet Arsenal. Copper cylinders of 9,000 pounds initial compression and tables of 1887. Electric primers, model 1883. | |
| *Pounds.* | *Ft.* | *In.* | | |
| No. 4, less than 9,000. | 8 | 4 | Pressure plug in bottom of cartridge bag.<br>Fired from platform 18 inches high on field platform. Restrained in recoil by a rope attached to a post in front of platform. Fired into field butt.<br>Elevating clamp failed to hold mortar in position when it was fired and was difficult to unlock.<br>Breech mechanism worked well throughout the firing, except that slide for opening locking device of breechblock did not automatically uncover the vent when breechblock was locked. | Shell struck ground 300 feet in front of platform. Breechblock closed and opened easily. Obturation good. Velocity wires not cut. |
| No. 4, 11,090 | 8 | 10 | | Velocity wires not cut. |
| No. 4, 13,380 | 0 | 10 | | |
| No. 4, 14,600 | 0 | 13 | | Rope restraining recoil broke. |
| | | | Firing conducted by the proof officer, except round 4, which was conducted by Capt. J. C. Ayres, O. D. Present, Capt. R. Birnie, jr., O. D. | |

**to test mortar.]**

| | | | | |
|---|---|---|---|---|
| | | | Mortar mounted on new experimental mortar carriage made at Watervliet Arsenal. Copper cylinders of 9,000 pounds initial compression and tables of 1887. Electric primers, model 1883. | |
| No. 4, 13,500 | 11 | 6 | Pressure plug in bottom of cartridge bag on right side.<br>The clamp wheel does not hold the piece at the elevation given, and is hard to release after firing.<br>Fired from platform 18 inches high on field platform. Restrained in recoil by a rope attached to a post in front of platform. Fired into field butt. | |
| No. 4, 14,930 | 11 | 6 | | Velocity wires not cut. |
| No. 4, 19,650 | 12 | 0 | | |
| No. 4, 15,660 | 12 | 0 | | Velocity wires not cut. |

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1, Watert*

[Object of tr

| Date. | | No. of fire. | Powder. | | | Projectile. | | | Travel of shot in bore. | Elevation. | | [illegible] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | | Kind. | Weight. | | | | | |
| | | | | *Lbs.* | *Oz.* | | *Lbs.* | *Oz.* | *Inches.* | ° | ′ | [illegible] |
| 1889. | | | | | | | | | | | | |
| Dec. 20 | A. M...... | 9 | Du Pont's I. K. F. Density, 1.725. Granulation, 2,016. | 1 | 0 | Shell (banded), experimental. Lot 246. | 19<br>13 sand.<br>20 | 3<br><br>0 | 16.17 | 0 | 40 | [illegible] |
| | | 10 | | 1 | 0 | | 19<br>15 sand.<br>20 | 1<br><br>0 | 16.16 | 0 | 40 | [illegible] |
| | | 11 | Du Pont's square L. X. Q. Density, 1.725. Granulation, 275. | 0 | 14 | | 19<br>14 sand.<br>20 | 2<br><br>0 | ........ | 0 | 40 | [illegible] |
| | | 12 | | 0 | 15 | | 19<br>13 sand.<br>20 | 3<br><br>0 | 16.17 | 0 | 40 | [illegible] |
| | | 13 | | 0 | 15 | | 19<br>12 sand.<br>20 | 4<br><br>0 | ........ | 45 | 00 | ..... ..... |
| Dec. 23 | A. M..... | 14 | King's mortar powder. Lot 3. Density, 1,772. | 0 | 15 | Shell (banded), experimental. Lot 249. | 19<br>12 sand.<br>20 | 4<br><br>0 | 16.16 | ........ | | [illegible] |
| | | 15 | | 0 | 15 | | 19<br>14 sand.<br>20 | 2<br><br>0 | 16.17 | ........ | | [illegible] |
| | | 16 | | 0 | 15 | | 19<br>14 sand.<br>20 | 2<br><br>0 | 16.17 | ........ | | [illegible] |

*Arsenal, at Sandy Hook, N. J., from December 20 to December 23, 1889.*

to test mortar.]

| Pressure per square inch of bore. | Recoil. | | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|---|
| *Pounds.* | *Ft.* | *In.* | Mortar mounted on new experimental mortar carriage made at Watervliet Arsenal. Copper cylinders of 9,000 pounds initial compression and tables of 1887. Electric primers, model 1883. | |
| No. 4, 15,130 | 10 | 0 | Auxiliary platform moved off field platform on sand 10 feet from first velocity target. Mortar fired from this position after round 8.<br>Fired in direction of 3,000-yards target. Fired from planks laid on sand.<br>Slide for operating the locking device for the breechblock worked badly throughout the firing. It did not entirely uncover the vent when closed, and was difficult to manipulate in unlocking the block. | |
| No. 4, 15,625 | 10 | 0 | | Breechblock closed with slight difficulty. |
| No. 4, 16,170 | 10 | 0 | | Velocity wires of first target not cut. |
| No. 4, 17,080 | 11 | 0 | | |
| No. 4, 17,040 | 5 | 0 | | First primer failed to explode. Observers were unable to follow the flight of the shell. |
| | | | Firing conducted by the proof officer, except rounds 5, 6, and 7, which were conducted by Capt. J. C. Ayres, O. D. Present, Capt. R. Birnie, jr., O. D.<br>Mortar mounted on new experimental mortar carriage made at Watervliet Arsenal. Copper cylinders of 9,000 pounds initial compression and tables of 1887. Electric primers, model, 1883. | |
| No. 4, 17,590 | ........ | | Pressure plug in bottom of cartridge bag on right side.<br>Fired from platform 18 inches high. Restrained in recoil by a rope attached to a post in front of platform; platform 40 feet in front of field platform. Fired into field butt. | Mortar recoiled off platform; too much slack rope. |
| No. 4, 18,100 | ........ | | | Elevating device not used. Block and wedges used to give elevation. Recoil to end of rope; rope 11 feet long. |
| No. 4, 17,080 | ........ | | | Powder weighed on office scales. Clamp wheel found to be tightened after firing. Recoil to end of rope; rope 10 feet long. |

# APPENDIX 37.

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### *TEST OF THE 3.6-INCH BREECH-LOADING RIFLED MORTAR, BY THE BOARD FOR TESTING RIFLED CANNON, ETC., APPOINTED UNDER THE ACT OF CONGRESS APPROVED JULY 5, 1834.*

(Fifteen plates.)

The 3.6-inch B. L. R. mortar was turned over to this Board at the Ordnance Proving Ground, Sandy Hook, N. J., for trial, in accordance with instructions of the Chief of Ordnance, U. S. Army, dated December 6, 1890. A general description of the piece will be found in the report of the Chief of Ordnance, U. S. Army, for 1890.

After round 70 the following alterations were made in the bore and breech mechanism. The bore at shot seat was made conical from 3.64 inches diameter to 3.6 inches for a length of 6.7 inches. The original catch and stud for locking breechblock was replaced by a locking stud on the left side of the block, whose handle bears also a vent shield. A projecting stud in the base of the breech actuates the locking piece of the carrier ring.

#### TEST OF THE PIECE.

The Board determined on the following conditions for the test of this piece:

##### TEST FOR ENDURANCE.

Five hundred rounds, to be fired with full charges of 1 pound of powder and projectiles of 20 pounds; the pressures to be limited to about 18,000 pounds.

##### TEST FOR ACCURACY.

Ten targets, of 10 shots each, with projectiles especially provided for this test, as follows:

Six targets with 1 pound charge; one at each angle of elevation, as follows: 45°, 40°, 35°, 30°, 25°, 15°.
One target with 11 ounces charge at 15° elevation.
One target with 8 ounces charge at 15° elevation.
One target with 5 ounces charge at 15° elevation.
One target with 3 ounces charge at 15° elevation.

A test for rapidity was also made. In this test the time of firing 50 rounds was noted; also the times of two separated groups of 10 shots each.

#### FIRINGS.

Two hundred and twenty-two rounds had been fired from the piece before it came into the hands of the Testing Board; of these 12 were with charges of 1 pound 2 ounces, 91 with charges of 1 pound, and 119 with reduced charges. At completion of the firing tests 714 rounds have been fired, 518 of these being with full charges.

### CARRIAGE

When turned over to the Board the piece was mounted on a carriage of cast steel, cast in a single piece. The carriage sustained no injuries during the test.

### POWDER.

In previous firings the best results, as regards velocities and pressures, were obtained with Du Pont's sphero-hexagonal powder, U. S.; density, 1.72; granulation, 123. As none of this powder was on hand at the proving ground, the tests were carried on with Du Pont's I. K. H. powder; density, 1.725; granulation, 2,524. Table 1 exhibits the results obtained with each of these powders with projectiles of 20 pounds weight.

TABLE 1.—*Velocities and pressures.*

| Kind of powder. | No. of rounds. | Weight of charge. | Mean instrumental velocity. | At distance from muzzle. | Mean pressure. | Greatest pressure. |
|---|---|---|---|---|---|---|
| | | *Ounces.* | *Feet-sec.* | *Feet.* | *Pounds.* | *Pounds.* |
| Sphero-hexagonal...... | 3 | 16 | 642 | 50 | 14,892 | 16,570 |
| | 2 | 11 | 521 | 50 | 9,400 | 9,450 |
| | 1 | 8 | Lost, | .......... | 7,590 | 7,590 |
| I. K. H................ | 3 | 16 | 640 | 50 | 15,707 | 16,570 |
| | 3 | 11 | 506 | 50 | 9,358 | 9,600 |
| | 3 | 8 | *416 | 20 | 6,200 | 6,530 |
| | 1 | 5 | Lost. | .......... | 3,500 | 3,500 |

* Mean of two rounds.

### PROJECTILES.

The projectiles used throughout the tests were cast-iron shell, with single copper bands, and weighted with sand to 20 pounds. For the accuracy tests a special lot of 100 shell, similar to those to be issued for service, was provided. The shell of this lot had a front bearing half an inch long and 3.59 inches in diameter.

### RANGE AND ACCURACY.

The first five of the series of accuracy tests, as shown in Table 2, following, were made with the shell especially provided and described above. The other targets with these shell were lost through some of the shell falling in the sea. The targets made with 16-ounce charges and 30, 35, and 45 degrees of elevation were made with the special shell rebanded, while those made at 25 and 40 degrees of elevation were made with the ordinary shell on hand at the proving ground. The greatest range obtained in this series of tests was 3,413 yards with a charge of 16 ounces and elevation of 45°.

TABLE 2.

| harge. | Elevation. | Mean range. | Dispersion in range. | Mean lateral deviation. | Lateral dispersion. | Deviation from center of impact. |  | Time of flight. | Wind. |  |
|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  | Longitudinal. | Lateral. |  | Direction. | Force per hour. |
| unces. | ° | *Yards.* | *Yards.* | *Yards.* | *Yards.* | *Yards.* | *Yards.* | *Seconds.* |  | *Miles.* |
| 3...... | 15 | 321.3 | 39 | 3.2 | 2 | 12.7 | 0.48 | 4 | F. and L... | 8 |
| 5...... | 15 | 533.9 | 62 | 4.7 | 1 | 19.28 | 0.43 | 5.5 | F. and L... | 8 |
| 8...... | 15 | 887.5 | 85 | 13.8 | 5 | 20.7 | 1.0 | 7.25 | Left....... | 10 |
| 1...... | 15 | 1216.5 | 122 | 16.9 | 3 | 21.1 | 0.72 | 8. | R. and R .. | 16 |
| 16...... | 15 | 1993.1 | 328 | 17.7 | 9 | 94.14 | 1.9 | 10.5 | Right. .... | 14 |
| 16...... | 25 | 2709.3 | 116 | 1.8 | 15 | 25.7 | 2.64 | 16.5 | Rear ...... | 22 |
| 10...... | 30 | 3000.3 | 141 | 33.4 | 37 | 43.56 | 1.0 | 19 | Rear ...... | 23 |
| 16...... | 35 | 3082.5 | 165 | 42.2 | 10 | 36.4 | 2.56 | .......... | F. and R .. | 9 |
| 16...... | 40 | 3164.1 | 230 | 44.3 | 21 | 62.14 | 4.50 | .......... | F. and R .. | 12 |
| 16...... | 45 | 3281.4 | 273 | 94.8 | 12 | 55 | 4.0 | 25.5 | Rear ...... | 15 |

## RAPIDITY.

The test for rapidity consisted of 50 consecutive rounds fired as rapidly as possible, and including two separate groups of 10 shots each, n firing which special exertion was made.

The firing detachment consisted of a noncommissioned officer and men, and as it was necessary to seek shelter at each round, and the nearest shelter was at a distance of 63 feet from the gun, the exertion of rapid firing entailed considerable fatigue on the men. With guns in service if shelter is not sought the rapidity of firing might be materially ncreased. The 50 rounds were fired in 56 minutes and 25 seconds, ncluding a delay of 3 minutes and 10 seconds required in repairing platform.

The two separate groups of 10 shots were fired in 8 minutes 30 seconds and 6 minutes 50 seconds respectively.

## ENDURANCE.

After round 222 the stops of vent shield were replaced by longer ones. At round 224 the upper breechblock handle was bent by the overturning of the mortar; not sufficiently, however, to interfere with the proper working of the breechblock. Between rounds 301 and 416 the vent shield was frequently bent by the discharge, and at the latter round it was broken. A new and stiffer vent shield was fitted to the piece after the four hundred and forty-fifth round. This shield was not bent by the discharge, but broke after 223 rounds. Seventy-four rounds were fired without the vent shield.

Other parts of the breech mechanism worked satisfactorily throughout the tests. When the piece became very foul difficulty was sometimes experienced in opening and closing the breech. The difficulty was easily removed by cleaning and oiling the block. The tip of the front sight was slightly injured and the sight partly unscrewed by the numerous overturnings of the piece and carriage.

At the completion of the tests the piece had sustained no injury that interfered materially with its proper working.

Table 3 exhibits the results of star gauging since the alterations of the bore, described above, were made.

## TABLE 3.

### CHAMBER.

| Inches from breech. | After round 90. | After round 694. | Enlargement. |
|---|---|---|---|
| | *Inches.* | *Inches.* | *Inch.* |
| 6¼ | 3.809 | 3.811 | 0.002 |
| 7¾ | 3.809 | 3.811 | 0.002 |
| 9¼ | 3.809 | 3.812 | 0.003 |

### LANDS.

| Inches from muzzle. | After round 90. | After round 694. | Enlargement. |
|---|---|---|---|
| | *Inches.* | *Inches.* | *Inch.* |
| 0.5 | 3.607 | 3.616 | 0.009 |
| 1.0 | 3.607 | 3.615 | 0.008 |
| 1.5 | 3.607 | 3.615 | 0.008 |
| 2.0 | 3.6065 | 3.615 | 0.0085 |
| 2.5 | 3.606 | 3.615 | 0.009 |
| 3.0 | 3.606 | 3.6145 | 0.0085 |
| 3.5 | 3.606 | 3.6145 | 0.0085 |
| 4.0 | 3.606 | 3.6145 | 0.0085 |
| 4.5 | 3.606 | 3.6145 | 0.0085 |
| 5.0 | 3.606 | 3.6145 | 0.0085 |
| 5.5 | 3.606 | 3.615 | 0.009 |
| 6.0 | 3.606 | 3.6155 | 0.0095 |
| 6.5 | 3.6065 | 3.616 | 0.0095 |
| 7.0 | 3.6065 | 3.616 | 0.0095 |
| 7.5 | 3.607 | 3.6165 | 0.0095 |
| 8.0 | 3.608 | 3.617 | 0.009 |
| 8.5 | 3.610 | 3.618 | 0.008 |
| 9.0 | 3.6115 | 3.620 | 0.0085 |
| 9.5 | 3.6155 | 3.623 | 0.0075 |
| 10.0 | 3.618 | 3.624 | 0.006 |
| 10.5 | 3.6205 | 3.627 | 0.0065 |
| 11.0 | 3.623 | 3.6295 | 0.0065 |
| 11.5 | 3.626 | 3.6315 | 0.0055 |
| 12.0 | 3.628 | 3.6335 | 0.0055 |
| 12.5 | 3.632 | 3.636 | 0.004 |
| 13.0 | 3.634 | 3.6385 | 0.0045 |
| 13.5 | 3.637 | 3.6405 | 0.0035 |
| 14.0 | 3.638 | .......... | .......... |

## CONCLUSION.

The Board is of opinion that this piece has shown satisfactory endurance, 500 rounds with full charges having been fired without material damage beyond the breaking of the vent shield.

## OPINION.

In the opinion of the Board the 3.6 inches B. L. R. mortar (steel), No. 1, has been "subjected to the proper test, including such rapid firing as a like gun would be likely to be subjected to in actual battle, for the determination of the endurance of the same;" this to the satisfaction of the Board, and in the opinion of the Board pieces of this type may safely be put to use in the Government service.

A complete record of the firings of this piece is forwarded as a part of this report; also all the star-gauge records.

A. MORDECAI,
*Colonel, Ord. Dept., U. S. Army.*
GEO. W. MCKEE,
*Major, Ordnance Department.*
CHARLES SHALER,
*Captain, Ordnance Department.*
WM. W. GIBSON,
*First Lieut., Ordnance Department.*
ORMOND M. LISSAK,
*First Lieut., Ordnance Department.*

(1733-'91.)

*Record of firing with 3.6-inch B. L. field mortar (steel), No.*

[Object of fir

| Date. | | No. of fire. | Powder. Kind. | Powder. Weight. | Projectile. Kind. | Projectile. Weight. | Travel of shot in bore. | Elevation. | | Rem |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | *Lbs. Oz.* | | *Lbs. Oz.* | *Inches.* | ° | ′ | *F* |
| 1890. | | | | | | | | | | |
| Jan. 29 | P. M. | 38 | Du Pont's I. K. G. Density, 1.725. Granulation, 2,500. | 1 0 | Shell (banded), experimental. Lot 249. | 18 10<br>1 0 sand.<br>6 lead.<br>20 0 | 16.18 | 20 | 00 | 9 |
| | | 39 | | 1 0 | | 18 10<br>1 0 sand.<br>6 lead.<br>20 0 | 16.18 | 20 | 00 | 6 |
| | | 40 | | 1 0 | | 18 10<br>1 0 sand.<br>6 lead.<br>20 0 | 16.18 | 20 | 00 | 7 |
| | | 41 | | 1 0 | | 18 10<br>1 0 sand.<br>6 lead.<br>20 0 | 16.18 | 20 | 00 | 7 |
| | | 42 | | 1 0 | | 18 10<br>1 0 sand.<br>6 lead.<br>20 0 | 16.18 | 20 | 00 | 7. |

TARGET.

| No. of round. | Range. | Deviation. Right. | Deviation. Left. |
|---|---|---|---|
| | *Yards.* | *Feet.* | *Feet.* |
| 38 | 2,427 | ........ | 13 |
| 39 | 2,348 | ........ | 20 |
| 40 | 2,451 | 6.166 | ........ |
| 41 | 2,388 | 4.116 | ........ |
| 42 | 2,380 | ........ | 4.416 |

Greatest range ............................ yards.. 2

Least range ............................ do... 2

Dispersion in range ............................ do...

Greatest deviation to left ............................ feet.. 20

Greatest deviation to right ............................ do.. 6.16

Lateral dispersion ............................ do.. 26

*Watervliet Arsenal, at Sandy Hook, N. J., January 29, 1890.*

to determine range.]

| Wind, strength and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|
| From right, 29 miles an hour. | Mortar mounted on new experimental carriage made at Watervliet Arsenal. Electric primers, model 1883.<br>Elevating crank removed after thirty-eighth round.<br>Fired from platform 18 inches high. Recoil restrained by a rope attached to a post in front of platform.<br>Axle of elevating gear reversed; crank end on right side of carriage.<br>Fired down the beach.<br>Quadrant applied to face of piece in giving elevation.<br>Sighted on left edge of old 1-mile target.<br>Firing conducted by the proof officer. | Clamp nut found unclamped after firing. Elevation after firing, 33°.<br>Clamp nut found unclamped after firing. Elevation after firing, 38° 40′.<br>Clamp nut found unclamped after firing. Elevation after firing, 40° 55′. Right maneuvering bolt bent.<br>Right maneuvering bolt still further bent by carriage running up on left side rails of platform in recoil; carriage tipping on right side, maneuvering bolt striking platform. Elevation after firing, 40° 55′. Clamp nut unclamped slightly.<br>Carriage ran up on left side; right maneuvering bolt struck platform. Elevation after firing, 26° 30′. |

TARGET.

| No. of round. | Range. | Lateral deviation from plane of reference. | | From center of impact, longitudinal. | | From center of impact, lateral. | |
|---|---|---|---|---|---|---|---|
| | | Right. | Left. | + | − | Right. | Left. |
| | *Yards.* | *Feet.* | *Feet.* | *Yds.* | *Yds.* | *Feet.* | *Feet.* |
| 38...... | 2,427 | ........ | 13 | 28.2 | ...... | ........ | 7.5732 |
| 39...... | 2,348 | ........ | 20 | ...... | 50.8 | ........ | 14.5732 |
| 40...... | 2,451 | 6.166 | ........ | 52.2 | ...... | 11.5928 | ........ |
| 41...... | 2,388 | 4.116 | ........ | ...... | 10.8 | 9.5428 | ........ |
| 42...... | 2,380 | ........ | 4.416 | ...... | 18.8 | 1.0108 | ........ |
| | 11,994 | 10.282 | 37.416 | 80.4 | 80.4 | 22.1464 | 22.1464 |

| | |
|---|---|
| Mean range .......... yards.. | 2,398.8 |
| Mean lateral deviation from plane of reference .....feet.. | 5.4268 |
| Mean longitudinal deviation from center of impact..yds.. | 32.16 |
| Mean lateral deviation from center of impact ......feet.. | 8.8585<br>=2.9528 yards. |

11,994 ÷ 5 = 2,398.8 $\left(\begin{matrix}37.416-10.282=27.134\\ \div 5=5.4268\end{matrix}\right)$ 160.8 ÷ 5 = 32.16 44.2928 ÷ 5 = 8.8585

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1, Watervli*

[Object of firing, to obta

| Date. | | No. of fire. | Powder. | | Projectile. | | Travel of shot in bore. | Elevation. | Instrumental velocity 35 feet from muzzle. |
|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1890. | | | | *Lbs. Oz.* | | *Lbs. Oz.* | *Inches.* | ° ′ | *Feet.* |
| Jan. 30 | P. M...... | 43 | Du Pont's I. K. G. Density, 1.725. Granulation, 2,500. | 0 15 | Shell (banded), experimental. Lot 249. | 19 3<br>13 sand.<br>20 0 | 16.18 | 0 55 | 623<br>[illegible]<br>[illegible] |
| | | 44 | | 0 15 | | 18 15<br>1 1 sand.<br>20 0 | 16.18 | 0 55 | Lost .. |
| | | 45 | | 0 15 | | 18 13<br>1 3 sand.<br>20 0 | 16.18 | 0 55 | Lost .. |
| | | 46 | | 0 15 | | 18 11<br>1 5 sand.<br>20 0 | 16.18 | 0 55 | Lost ... |
| | | 47 | | 0 15 | | 18 11<br>1 5 sand.<br>20 0 | 16.18 | 0 55 | 639<br>[illegible]<br>[illegible]<br>10–[illegible] |
| Feb 3 | P. M...... | 48 | Du Pont's I. K. G. Density, 1.725. Granulation, 2,500. | 0 15 | Shell (banded), experimental. Lot 249. | 18 9<br>1 0 sand.<br>7 lead.<br>20 0 | 16.18 | 0 55 | Lost.<br>625<br>62[illegible] |
| | | 49 | | 0 15 | | 18 9<br>1 0 sand.<br>7 lead.<br>20 0 | 16.18 | 0 55 | Lost ... |
| | | 50 | | 0 15 | | 18 9<br>1 0 sand.<br>7 lead.<br>20 0 | 16.18 | 1 00 | 614<br>616<br>615 |

*Arsenal, at Sandy Hook, N. J., from January 30 to February 3, 1890.*

velocities and pressures.]

| Pressure per square inch of bore. | Recoil. | Wind, strength and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|---|
| *Pounds.* | *Feet.* | | Mortar mounted on new experimental carriage made at Watervliet Arsenal. Copper cylinders of 9,000 pounds initial compression and tables of 1887. Electric primers, model 1883. | |
| No. 4, 16,700 | 8¼ | ........ | Elevating crank removed after firing.<br>Wooden bolster placed between cheeks of carriage under breech.<br>Pressure plug in bottom of cartridge bag on right side.<br>Fired from platform 18 inches high.<br>Recoil restrained by a rope attached to post in front of platform.<br>Fired to sea.<br>In recoiling, the carriage tends to rotate to rear and rises from the platform. The action of the restraining rope is to cause the carriage to jump from platform and in coming down to strike on the rear end and then move forward.<br>On account of low velocity of projectile and ductility of wire, much difficulty found in obtaining record of velocity. Targets of different construction are being prepared. | Elevation after firing, 1° 40′. Clamp nut found clamped after firing. |
| No. 4, 15,750 | ........ | ........ | | Recoiled to end of rope and counter recoiled 15 inches. Elevation after firing, 1° 55′. First set of velocity wires on second target not cut. Clamp nut found unclamped after firing. |
| No. 4, 16,570 | ........ | ........ | | Recoiled to end of rope and counter recoiled about 15 inches. Clamp nut found unclamped after firing. After firing, the mortar was found depressed 20′. Mortar fired before instruments were ready. |
| No. 4, 16,820 | ........ | ........ | | Recoiled to end of rope and counter recoiled about 15 inches. Elevation after firing, 10′. Clamp nut found unclamped after firing. |
| No. 4, 16,700 | ........ | ........ | | Mortar recoiled full length of rope and jumped off platform and fell sideways on sand. Right rail of bed of carriage breaking through notch for rear bolt that assembles top carriage to bed. The shoe on this rail has been bending during several previous firings and the wood giving, but at last round (forty-seventh) break became more pronounced. |
| | | | Firing conducted by the proof officer.<br>Mortar mounted on new experimental carriage made at Watervliet Arsenal. Electric primers, model 1883. Copper cylinders of 9,000 pounds initial compression and tables of 1887. | |
| No. 4, 17,100 | ........ | ........ | Crank handle omitted during firing. Wooden bolster placed between cheeks of carriage under breech.<br>Pressure plug in bottom of cartridge bag on right side.<br>Fired into field butt, section 1.<br>Brass wire B. T. No. 27 tried on velocity frames in rounds 48 and 49.<br>In round 50 No. 20 wire was closely strung on velocity frames without using insulators.<br>Fired from platform 18 inches high. Recoil restrained by a rope attached to a post in front of platform.<br>Elevating crank omitted during firing. | Mortar recoiled full length of rope and fell over on right side of platform. Clamp nut found unclamped after firing. Velocity wires of first target not cut. |
| No. 4, 16,000 | | | | Mortar recoiled full length of rope and fell over on right side on platform. First set of velocity wires on first target not cut. Clamp nut found unclamped after firing. Second set of velocity wires in second target not cut. |
| No. 4, 16,250 | ........ | ........ | | Mortar recoiled full length of rope and jumped off platform, falling on right side on sand. Clamp nut found unclamped after firing. The break in right rail of bed of carriage at notch for rear bolt that assembles top carriage to bed, and the binding of shoe on this rail is still developing. |
| | | | Firing conducted by Lieut. W. W. Gibson, O. D., assistant proof officer. | |

*Record of firing with 3.6-inch B. L. field mortar (steel). N*

[Object of firing, accu-

| Date. | | No. of fire. | Powder. Kind. | Powder. Weight. | Projectile. Kind. | Projectile. Weight. | Travel of shot in bore. | Elevation. | In- |
|---|---|---|---|---|---|---|---|---|---|
| 1890. | | | | *Lbs. Oz.* | | *Lbs. Oz.* | *Inches.* | ° ' | *Fe* |
| Feb. 4 | ............ | 51 | Du Pont's I. K. G. Density, 1.725. Granulation, 2,500. | 1 0 | Shell (banded), experimental. Lot 249. | 18 12<br>1 4 sand.<br>20 0 | 16.18 | 45 00 | .... |
| | | 52 | | 1 0 | | 18 9<br>1 0 sand.<br>7 lead.<br>20 0 | 16.18 | 45 00 | ...... |
| | | 53 | | 1 0 | | 18 10<br>1 0 sand.<br>6 lead.<br>20 0 | 16.18 | 45 00 | ..... |
| | | 54 | | 1 0 | | 18 10<br>1 0 sand.<br>6 lead.<br>20 0 | 16.18 | 45 00 | .... |
| | | 55 | | 1 0 | | 18 10<br>1 0 sand.<br>6 lead.<br>20 0 | 16.18 | 45 00 | ..... |
| | | 56 | | 1 0 | | 18 10<br>1 0 sand.<br>6 lead.<br>20 0 | 16.18 | 45 00 | .... |
| | | 57 | | 1 0 | | 18 10<br>1 0 sand.<br>6 lead<br>20 0 | 16.18 | 45 00 | .... |

*Watervliet Arsenal, at Sandy Hook, N. J., February 4, 1890.*

**at maximum range.]**

| Pressure per square inch of bore. | Recoil. | Wind, strength and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|---|
| *Pounds.* | *Feet.* | | Mortar mounted on new experimental carriage made at Watervliet Arsenal. Electric primers, model 1883. | |
| ............ | ........ | Wind from right and rear, 10 miles an hour. | Fired from platform 18 inches high. Recoil restrained by a rope 12 feet long attached to a post in front of platform.<br>Elevating crank omitted during firing.<br>Mortar sighted at range stake to left of sand butt.<br>Three shots, numbers unknown<br>Range, yds. / Deviation right, yds.<br>3,347 / 162<br>3,431 / 158<br>3,456 / 194<br>One shot lost; number of it unknown. | Sighting shot. Mortar recoiled full length of rope. Elevation after firing, 47° 20′. |
| ............ | ........ | | | Sighting shot. Mortar recoiled full length of rope. Elevation after firing, 48°. Clamp not found clamped after firing. Breechblock closed and opened with difficulty. |
| ............ | ........ | | | Mortar recoiled full length of rope, rebounded and jumped up on side rail of platform. Breechblock opened with difficulty. Range, 3,323 yards. Deviation right, 162 yards. |
| ............ | ........ | | | Mortar recoiled full length of rope. Breechblock opened with difficulty. Range, 3,446 yards. Deviation, 158 yards right. |
| ............ | ........ | | | Mortar recoiled full length of rope. Breechblock opened with slight difficulty. |
| ............ | ........ | | | Mortar recoiled full length of rope. Breechblock opened with slight difficulty. Range, 3,419 yards. Deviation right, yards 162. |
| ............ | ........ | | | Mortar recoiled full length of rope. |
| | | | Firing conducted by the proof officer. | |

*Record of firing with 3.6-inch B. L. field mortar (steel).*

[Object of firing,

| Date. | | No. of fire. | Powder. | | Projectile. | | Travel of shot in bore. | Elevation. | [illegible] 35 [illegible] from |
|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1890. | | | | *Lbs. Oz.* | | *Lbs. Oz.* | *Inches.* | ° ′ | [illegible] |
| Feb. 7 | A. M...... | 58 | Du Pont's I. K. G. Density, 1.725. Granulation, 2,500. | 0 15 | Shell (banded), experimental. Lot 249. | 19 2<br>14 sand.<br>20 0 | 16.18 | 0 50 | [illegible] |
| | | 59 | | 0 15 | | 19 0<br>1 0 sand.<br>20 0 | 16.18 | 0 50 | [illegible] |
| | | 60 | | 0 15 | | 18 9<br>1 0 sand.<br>7 lead.<br>20 0 | 16.18 | 0 50 | [illegible] |
| | | 61 | | 0 15 | | 18 9<br>1 0 sand.<br>7 lead.<br>20 0 | 16.18 | 0 50 | [illegible] |
| | | 62 | | 0 1 | | 18 12<br>1 4 sand.<br>20 0 | 16.18 | 0 50 | [illegible] |
| | | 63 | | 1 0 | | 19 5<br>11 sand.<br>20 0 | 16.18 | 0 50 | [illegible] |
| | | 64 | | 0 1 | | 19 5<br>11 sand.<br>20 0 | 16.18 | 0 50 | [illegible] |

*Watervliet Arsenal, at Sandy Hook, N. J., February 7, 1890.*

**velocities and pressures.]**

| Pressure per square inch of bore. | Recoil. | Wind, strength and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|---|
| *Pounds.* | *Feet.* | | Mortar mounted on new experimental carriage made at Watervliet Arsenal. Copper cylinders of 9,000 pounds initial compression and tables of 1887. Electric primers, model 1883. | |
| No. 4, 16,820 | ........ | .......... | Fired from platform 18 inches high. Recoil restrained by a rope attached to a post in front of platform.<br>Elevating crank omitted during firing.<br>Wooden bolster placed between cheeks of carriage under breech.<br>Fired into field butt, section 1.<br>Pressure plug in bottom of cartridge bag, on right side. | Mortar recoiled full length of rope. |
| No. 4, 15,000 | ........ | .......... | | Mortar recoiled full length of rope. |
| No. 4, 15,800 | ........ | .......... | | Mortar recoiled full length of rope. |
| No. 4, 15,910 | ........ | .......... | | Mortar recoiled full length of rope. Rope restraining recoil broke. |
| ............ | ........ | .......... | | Mortar recoiled full length of rope. |
| ............ | ........ | .......... | | Mortar recoiled full length of rope, and jumped off platform, falling on right side on sand. |
| ............ | ........ | .......... | | Rope restraining recoil broke. Mortar jumped off platform, falling on sand. The break in right rail of bed of carriage at notch for rear bolt that assembles top carriage to bed and the bending of shoe on this rail continues to develop. |
| | | | Firing conducted by Lieut. W. W. Gibson, O. D., assistant proof officer. | |

*Record of firing with 3.6-inch B. L. field mortar (steel), No.*

[Object of firing.

| Date. | | No. of fire. | Powder. | | Projectile. | | Travel of shot in bore. | Elevation. | Instr |
|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | | |
| | | | | *Lbs. Oz.* | | *Lbs. Oz.* | *Inches.* | ° ′ | *Feet* |
| 1890. Feb. 10 | A. M. | 65 | Du Pont's I. K. G. Density, 1.725. Granulation, 2,500. | 1 0 | Shell (banded), experimental. Lot 249. | 19 1<br>15 sand.<br>20 0 | 16.18 | 45 00 | ..... |
| | | 66 | | 1 0 | | 19 1<br>15 sand.<br>20 0 | 16.18 | 45 00 | ..... |
| | | 67 | | 1 0 | | 19 1<br>15 sand.<br>20 0 | 16.18 | 45 00 | ..... |
| | | 68 | | 1 0 | | 19 1<br>15 sand.<br>20 0 | 16.18 | 45 00 | ..... |
| | | 69 | | 1 0 | | 19 1<br>15 sand.<br>20 0 | 16.18 | 45 00 | ..... |
| | | 70 | | 1 0 | | 19 1<br>15 sand.<br>20 0 | 16.18 | 45 00 | ..... |

TARGET.

| No. of round. | Range. | Deviation | |
|---|---|---|---|
| | | Right. | Left. |
| | *Yards.* | *Yards.* | *Yards.* |
| 66 | 3,438 | 17 | ........ |
| 67 | 3,435 | ........ | 24 |
| 68 | 3,455 | ........ | 16 |
| 69 | 3,483 | 50 | ........ |
| 70 | 3,417 | 33 | ........ |

Greatest range ....................................

Least range ....................................

Dispersion in range ....................................

Greatest deviation to right ....................................

Greatest deviation to left ....................................

Lateral dispersion ....................................

Twenty rounds have been fired at Watervliet Arsenal. Chargo, 1 pound powder and 20-pound jectile.

Since round 70 mortar and carriage sent to Watervliet Arsenal and the following changes made

*Mortar.*—Bore at shot seat made conical from 3.64 inches to 3.6 inches for a length of 6.7 Catch and stud for locking breechblock omitted. Locking stud placed on left side of breechblock catch actuating a vent shield. Stud placed on breech of gun to actuate locking stud of carrier

*Carriage.*—Clamp wheel and clamp omitted from elevating apparatus. Axle reversed in its ings, and new clamp nut placed on right side of carriage. New wooden bed made uniform in throughout. The two maneuvering bolts replaced by iron loops.

Mortar star gauged before round 91, August 12, 1890, by Lieut. O. M. Lissak, O. D.

*Watervliet Arsenal, at Sandy Hook, N. J., February 10, 1890.*

at maximum range.]

| Pressure per square inch of bore. | Recoil. | Wind, strength and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|---|
| *Pounds.* | *Feet.* | | Mortar mounted on new experimental carriage made at Watervliet Arsenal. Electric primers, model 1883. | |
| ............ | ........ | From left to right, 18 miles an hour. | Fired from platform 18 inches high. Recoil restrained by a rope 10 feet long attached to a post in front of platform.<br>Elevating crank omitted during firing.<br>Fired down the beach. | Sighting shot. Elevation after firing, 55° 10′. Mortar recoiled full length of rope. Clamp nut remained clamped. |
| ............ | 6 | | | Clamp nut remained clamped. Elevation after firing, 56° 15′. |
| ............ | 7 | | | Clamp nut found unclamped after firing. Elevation after firing, 65°. |
| ............ | 6 | | | Clamp nut found unclamped after firing. Elevation after firing, 65°. |
| ............ | 6 | | | Elevation after firing, 40°. Clamp nut remained clamped. |
| ............ | 6 | | | Elevation after firing, 63° 20′. Clamp nut found unclamped after firing. Platform was found to have moved about 6 inches directly to the rear, 2 middle ties under platform having become loosened from platform and rotated. |
| | | | Firing conducted by Lieut. W. W. Gibson, O. D., assistant proof officer. | |

TARGET.

| No. of round. | Range. | Lateral deviation from plane of reference. | | From center of impact, longitudinal. | | From center of impact, lateral. | |
|---|---|---|---|---|---|---|---|
| | | Right. | Left. | + | − | Right. | Left. |
| | *Yards.* | *Yds.* | *Yds.* | *Yards.* | *Yards.* | *Yards.* | *Yards.* |
| 66...... | 3,438 | 17 | ...... | ........ | 7.6 | 5 | ........ |
| 67...... | 3,435 | ...... | 24 | ........ | 10.6 | ........ | 36 |
| 68...... | 3,456 | ...... | 16 | 9.4 | ........ | ........ | 28 |
| 69...... | 3,483 | 50 | ...... | 37.4 | ........ | 38 | ........ |
| 70...... | 3,417 | 33 | ...... | ........ | 28.6 | 21 | ........ |
| | 17,228 | 100 | 40 | 46.8 | 46.8 | 64 | 64 |

| | *Yards.* |
|---|---|
| Mean range.................... | 3,445.6 |
| Mean lateral deviation from plane of reference, right..... | 12 |
| Mean longitudinal deviation from center of impact....... | 18.72 |
| Mean lateral deviation from center of impact................ | 25.6 |

17,228÷5=3,445.6.    100—40=60÷5=12.    93.6÷5=18.72.    128÷5=25.6.

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1, Water-*

[Object of firing, to test sur-

| Date. | | No. of fire. | Powder. | | | Projectile. | | | Travel of shot in bore. | Elevation. | | Inst[illegible] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | | Kind. | Weight. | | | | | |
| | | | | *Lbs.* | *Oz.* | | *Lbs.* | *Oz.* | *Inches.* | ° | ' | *Feet.* |
| 1890. | | | | | | | | | | | | |
| Aug. 13 | P. M ..... | 91 | .......... | 1 | 0 | .......... | 19<br><br>20 | 3<br>13 sand.<br>0 | 16.1625 | 0 | 45 | [illegible] |
| | | 92 | .......... | 1 | 0 | .......... | 19<br><br>20 | 1<br>15 sand.<br>0 | 16.1625 | 0 | 45 | [illegible] |
| | | 93 | .......... | 1 | 0 | .......... | 19<br><br>20 | 4<br>12 sand.<br>0 | 16.1625 | 0 | 45 | [illegible] |
| | | 94 | .......... | 1 | 0 | .......... | 19<br><br>20 | 4<br>12 sand.<br>0 | 16.1625 | 0 | 45 | [illegible] |
| | | 95 | .......... | 1 | 0 | .......... | 19<br><br>20 | 4<br>12 sand.<br>0 | 16.1625 | 0 | 45 | [illegible] |
| Aug. 25 | P. M ..... | 96 | Du Pont's I. K. H. Density 1.725. Granulation 2,050. | 1 | 0 | Shell (banded), experimental. Lot 249. | 19<br><br>20 | 3<br>13 sand.<br>0 | 16.1625 | 0 | 45 | ......... |
| | | 97 | | 1 | 0 | | 19<br><br>20 | 4<br>12 sand.<br>0 | 16.1625 | 0 | 45 | ......... |
| | | 98 | | 1 | 0 | | 19<br><br>20 | 3<br>13 sand.<br>0 | 16.1625 | 0 | 45 | ......... |
| | | 99 | | 1 | 0 | | 19<br><br>20 | 4<br>12 sand.<br>0 | 16.1625 | 0 | 45 | ......... |
| | | 100 | | 0 | 11 | | 19<br><br>20 | 1½<br>14½ sand.<br>0 | 16.1625 | 0 | 45 | ......... |
| | | 101 | | 0 | 11 | | 19<br><br>20 | 1½<br>14½ sand.<br>0 | 16.1625 | 0 | 45 | ......... |
| | | 102 | | 0 | 11 | | 19<br>1<br>20 | 0<br>0 sand.<br>0 | 16.1625 | 0 | 45 | ......... |

*Arsenal, at Sandy Hook, N. J., from August 13 to August 25, 1890.*

ability of powder for mortar.]

| Pressure per square inch of bore. | Recoil. | | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|---|
| *Pounds.* | *Ft.* | *In.* | Mortar mounted on experimental carriage made at Watervliet Arsenal. Cannon friction primers (experimental), modified priming, March, 1890. | |
| No. 4, 18,660 | 11 | 8 | Fired from wooden platform of 4-inch plank 14 feet long. Recoil restrained by rope attached to round post 10 feet in front of platform and to chain through front loops of carriage. Rope allows recoil of 11 feet.<br>Fired down the beach.<br>Pressure plug in bottom of cartridge bag, on right side.<br>Copper cylinders of 18,000 pounds initial compression and tables of 1887 used in rounds 92 to 95, inclusive. | Rope drawn taut from carriage and given one round turn about post. Chain through loops of carriage broken. Clamp of elevating apparatus loosened by discharge and muzzle of mortar pointed upward. Copper cylinder of 9,000 pounds initial compression and tables of 1887. |
| No. 4, 18,200 | 10 | 0 | | Two turns of rope taken about post. Chain attached to carriage broken. |
| No. 4, 18,480 | 11 | 0 | | Two turns of rope taken about post. |
| No. 4, 18,660 | 6 | 5 | | All slack in rope taken up by winding around post. Chain attached to carriage broken. First primer failed. |
| No. 4, 18,760 | 5 | 0 | | All slack in rope taken up by winding around post. Mortar tipped over on right side. First primer failed. |
| | | | Pressures and velocities taken by Lieut. O. M. Lissak, O. D. Firing conducted by Lieut. O. M. Lissak, O. D., assistant proof officer.<br>Mortar mounted on new experimental carriage made at Watervliet Arsenal. Cannon friction primers (experimental), with modified priming, March, 1890. | |
| No. 4, less than 18,000. | 13 | 0 | Fired from wooden platform of 4-inch plank 14 feet long.<br>Recoil restrained by 5-inch rope fastened to round post 10 feet in front of platform and attached to bight of rope spliced through loops of carriage.<br>Chain used through loops of carriage in previous firing has been replaced by 5-inch rope attached by eye splices through loops.<br>Rope parceled over splices.<br>Fired into field butt, section 1.<br>Copper cylinders of 9,000 pounds initial compression and tables of 1887 used in rounds 98–102, inclusive.<br>Velocities taken, but the results were incorrect, due to improper working of chronometer of instruments. | Rope allows recoil of 13 feet. Two turns of rope taken about post. Mortar recoiled off platform. Elevation changed after fire; amount not noted. First primer failed. Copper cylinders of 18,000 pound initial compression and tables of 1887. |
| No. 4, less than 18,000 | 10 | 0 | | Rope shortened to allow recoil of 11 feet. First primer failed. Three turns of rope taken about post. Elevation changed after fire; amount not noted. Copper cylinders of 18,000 pounds initial compression and tables of 1887. |
| No. 4, 17,000 | 6 | 0 | | Three turns of rope taken about post. |
| No. 4, 17,100 | 5 | 9 | | Three turns of rope taken about post. Elevation changed after fire; amount not noted. |
| No. 4, 10,060 | 5 | 0 | | Three turns of rope taken about post. Elevation after fire, 50 degrees. |
| No. 4, 10,835 | 11 | 0 | | Three turns of rope taken about post. Elevation after fire, 50 degrees. |
| No. 4, 10,600 | 11 | 0 | | Three turns of rope taken about post. Elevation after fire, 50 degrees. |
| | | | Pressure and velocities taken by Lieut. W. W. Gibson, O. D. Firing conducted by Lieut. O. M. Lissak, O. D., assistant proof officer. | |

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1,*

[Object of firing, to determine sui

| Date. |  | No. of fire. | Powder. |  | Projectile. |  | Travel of shot in bore. | Elevation. | Instrumental velocity from muzzle. |
|---|---|---|---|---|---|---|---|---|---|
|  |  |  | Kind. | Weight. | Kind. | Weight. |  |  |  |
| 1890. |  |  |  | *Lbs. Oz.* |  | *Lbs. Oz.* | *Inches.* | ° ′ | *50 feet* |
| Aug. 26 | A. M. .... | 103 | Du Pont's I. K. H. Density, 1.725. Granulation, 2,050. | 1 0 | Shell (banded), experimental. Lot 249. | 19 5<br>11 sand.<br>20 0 | 16.1625 | 0 45 | 635 |
|  |  | 104 |  | 1 0 |  | 19 2<br>14 sand.<br>20 0 | 16.1625 | 0 45 | 637 |
|  |  | 105 |  | 1 0 |  | 19 3<br>13 sand.<br>20 0 | 16.1625 | 0 45 | 640 |
|  |  | 106 |  | 0 11 |  | 19 4<br>12 sand.<br>20 0 | 16.1625 | 0 50 | 497 |
|  |  | 107 |  | 0 11 |  | 19 4<br>12 sand.<br>20 0 | 16.1625 | 0 50 | 502 |
|  |  | 108 |  | 0 11 |  | 19 3<br>13 sand.<br>20 0 | 16.1625 | 0 50 | 496 |
|  |  | 109 |  | 0 8 |  | 19 3<br>13 sand.<br>20 0 | 16.1625 | 0 50 | 407 |
|  |  | 110 |  | 0 8 |  | 19 5<br>11 sand.<br>20 0 | 16.1625 | 0 50 | 407 |
|  |  | 111 |  | 0 8 |  | 19 6<br>10 sand.<br>20 0 | 16.1625 | 0 50 | 411<br>$25+\frac{50}{2}$ |
|  |  | 112 |  | 0 5 |  | 19 1<br>15 sand.<br>20 0 | 16.1625 | 1 00 | *30 feet.*<br>Lost .... |
|  |  | 113 |  | 0 5 |  | 19 7<br>9 sand.<br>20 0 | 16.1625 | 1 00 | 309 |
|  |  | 114 |  | 0 5 |  | 19 1<br>15 sand.<br>20 0 | 16.1625 | 1 00 | Lost ... |
|  |  | 115 |  | 0 5 |  | 19 4<br>12 sand.<br>20 0 | 16.1625 | 1 00 | 318 |
|  |  | 116 |  | 0 5 |  | 18 14<br>1 2 sand.<br>20 0 | 16.1625 | 1 00 | Lost ....<br>$15+\frac{30}{2}$ |

*Watervliet Arsenal, at Sandy Hook, N. J., August 26, 1890.*

ability of powder for mortar.]

| Pressure per square inch of bore. | Recoil. | | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological date. |
|---|---|---|---|---|
| *Pounds.* | *Ft.* | *In.* | Mortar mounted on experimental carriage made at Watervliet Arsenal. Cannon friction primers (experimental), with modified priming, March, 1890. | |
| No. 4, 16,940 | 2 | 0 | Fired from wooden platform of 4-inch plank 14 feet long. Recoil restrained by 5-inch rope fastened to round post 10 feet in front of platform, and attached to bight of rope spliced through loops of carriage.<br>Fired into field butt, section 1.<br>Copper cylinders of 9,000 pounds initial compression and tables of 1887 used in rounds 103 to 108, inclusive.<br>Uncompressed copper cylinders and tables of 1890 used in rounds 109 to 115, inclusive.<br>One chronograph (No. 101) used. | Three turns of rope taken about post. Mortar turned over on left side. |
| No. 4, 17,000 | 11 | 0 | | Three turns of rope taken about post. |
| No. 4, 16,920 | 11 | 0 | | Three turns of rope taken about post. Mortar turned over on left side. |
| No. 4, 10,230 | 6 | 0 | | Three turns of rope taken about post. |
| No. 4, 9,815 | 6 | 0 | | Three turns of rope taken about post. First primer failed to ignite cartridge. |
| No. 4, 10,170 | 7 | 0 | | Three turns of rope taken about post. |
| No. 4, 6,825 | 4 | 0 | | Three turns of rope taken about post. |
| No. 4, 7,150 | 4 | 0 | | Three turns of rope taken about post. |
| No. 4, 6,435 | 4 | 0 | | Three turns of rope taken about post. |
| No. 4, 4,300 | 1 | 9 | | Four turns of rope taken about post. |
| No. 4, 3,725 | 0 | 9 | | Four turns of rope taken about post. |
| No. 4, 4,359 | 0 | 9 | Uncompressed copper cylinders and tables of 1890 used.<br>Fired into field butt, section 1.<br>One chronograph (No. 1) used. | Four turns of rope taken about post. |
| No. 4, 4,450 | 1 | 0 | | Four turns of rope taken about post. |
| No. 4, 4,200 | 0 | 9 | | Two primers failed. Friction composition in short tube ignited, but failed to ignite rifle powder in long tube. |

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1, Watervliet*

[Object of firing, to determine sui

| Date. | | No. of fire. | Powder. | | Projectile. | | Travel of shot in bore. | Elevation. | Instrumental velocity, 30 feet from muzzle. |
|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1890. | | | | *Lbs. Oz.* | | *Lbs. Oz.* | *Inches.* | ° ′ | *Feet.* |
| Aug. 26 | A. M..... | 117 | Du Pont's I. K. H. Density, 1.725. Granulation, 2,050. | 0 3 | Shell (banded), experimental. Lot 249. | 19 2<br>14 sand.<br>20 0 | 16.1625 | 1 00 | ......... |
| | | 118 | | 0 3 | | 19 0<br>1 0 sand.<br>20 0 | 16.1625 | 1 30 | ......... |
| | | 119 | | 0 3 | | 18 15<br>1 1 sand.<br>20 0 | 16.1625 | 3 00 | ......... |
| | | | | | | | | | *50 feet* |
| Aug. 28 | P. M..... | 120 | Du Pont's sphero-hexagonal N. N. Density, 1.720. Granulation, 123. | 1 0 | Shell (banded), experimental. Lot 249. | 19 3<br>13 sand.<br>20 0 | 16.1625 | 0 45 | 649 |
| | | 121 | | 1 0 | | 18 13<br>1 3 sand.<br>20 0 | 16.1625 | 0 45 | 633 |
| | | 122 | | 1 0 | | 19 1<br>15 sand.<br>20 0 | 16.1625 | 0 45 | 644 |
| | | 123 | | 0 11 | | 19 0<br>1 0 sand.<br>20 0 | 16.1625 | 0 50 | 522 |
| | | 124 | | 0 11 | | 19 0<br>1 0 sand.<br>20 0 | 16.1625 | 0 50 | 519 |
| | | 125 | | 0 8 | | 18 12<br>1 4 sand.<br>20 0 | 16.1625 | 0 50 | Lost .. |

*Arsenal, at Sandy Hook, N. J., from August 26 to August 28, 1890.*

ability of powder for mortar.]

| Pressure per square inch of bore. | Recoil. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|
| | | Mortar mounted on experimental carriage made at Watervliet Arsenal. Cannon friction primers (experimental), with modified priming, March, 1890. | |
| *Pounds.* | *Ft. In.* | | |
| No. 4, 4,200 | 7 | | Four turns of rope taken about post. |
| No. 4, 3,945 | ........ | Uncompressed copper cylinders and tables of 1890 used.<br>Fired into field butt, section 1.<br>One chronograph (No. 101) used. | |
| No. 4, 3,610 | ........ | | Four turns of rope taken about post. All slack in rope taken up. |
| | | Pressures and velocities taken by Lieut. O. M. Lissak, O. D. Firing conducted by Lieut. O. M. Lissak, O. D., assistant proof officer.<br>Six blank charges, 3 ounces each, Du Pont's I, K. H., density 1.725, fired to test suitability of cartridge bag with small charge. All charges ignited without difficulty.<br>Mortar mounted on new experimental carriage made at Watervliet Arsenal. Cannon friction primers (experimental), with modified priming, March, 1890. | |
| No. 4, 16,570 | 3 | | Three turns of rope taken about post. |
| No. 4, 13,545 | ........ | | Three turns of rope taken about post. |
| No. 4, 14,560 | 4 | Fired from wooden platform of 4-inch plank 14 feet long. Recoil restrained by 5-inch rope fastened to round post 10 feet in front of platform and attached to bight of rope spliced through loops of carriage. | Three turns of rope taken about post. |
| No. 4, 9,350 | 5 | Fired into field butt, section 1.<br>In rounds 123 to 125 powder inclosed in rectangular paper box. Base, 2¼ inches square; length, 3 inches. | Three turns of rope taken about post. Paper found in mortar partially consumed and holding fire. |
| No. 4, 9,450 | 9 | Copper cylinders of 9,000 pounds initial compression and tables of 1887 used in rounds 120 to 124, inclusive.<br>Elevation found changed after each fire. | Three turns of rope taken about post. Paper found in mortar partially consumed and holding fire. |
| No. 4, 7,590 | 6 | | Three turns of rope taken about post. Paper found in mortar partially consumed and holding fire. Uncompressed copper cylinders and tables of 1890. |
| | | Pressures and velocities taken by Lieut. O. M. Lissak, O. D.<br>Firing conducted by Lieut. O. M. Lissak, O. D., assistant proof officer. | |

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1.*

[Object of firing, to determine rang

| Date. | | No. of fire. | Powder. | | Projectile. | | Elevation. | Recoil. | Wind strength and direction |
|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1890. | | | | *Ounces.* | | *Lbs. Oz.* | ° ′ | *Inches.* | |
| Sept. 9 | A. M | 126 | Du Pont's I. K. H. Lot 1. Density, 1.725. Granulation, 2,050. | 3 | Shell (banded), experimental. Lot 249. | 19 1<br>15 sand.<br>20 0 | 15 00 | 7 | From front and left, 5 miles an hour. |
| | | 127 | | 3 | | 19 2<br>14 sand.<br>20 0 | 15 00 | 3½ | |
| | | 128 | | 3 | | 19 2<br>14 sand.<br>20 0 | 15 00 | 1 | |
| | | 129 | | 3 | | 19 4<br>12 sand.<br>20 0 | 15 00 | ........ | |
| | | 130 | | 3 | | 19 4<br>12 sand.<br>20 0 | 15 00 | ........ | |

TARGET.

| No. of round. | Range. | Deviation, right. |
|---|---|---|
| | *Yards.* | *Yards.* |
| 126 | 323 | 3 |
| 127 | 252 | 3 |
| 128 | 300 | 6 |
| 129 | 324 | 4 |
| 130 | 354 | 4 |

| | *Yards* |
|---|---|
| Greatest range | [illegible] |
| Least range | [illegible] |
| Dispersion in range | [illegible] |
| Greatest deviation from plane of reference | 6 |
| Least deviation from plane of reference | 3 |
| Lateral dispersion | [illegible] |

*Watervliet Arsenal, at Sandy Hook, N. J., September 9, 1890.*

corresponding to charge of powder.]

| Time of flight. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|
| | Mortar mounted on new experimental carriage. Cannon friction primers (experimental), with modified priming, March, 1890. | |
| *Secs.* | | |
| 4⅛ | Fired from wooden platform of 4-inch plank 14 feet long.<br>Recoil restrained by a 5-inch rope fastened to round post 10 feet in front of platform and attached to bight of rope spliced through loops of carriage.<br>Fired down the beach.<br>Direction given by wooden strip nailed on platform. | First primer failed to ingnite cartridge. |
| 4¼ | | |
| 4¼ | | |
| 4¼ | | |
| 4⅛ | | |

## TARGET.

| No. of round. | Range. | Lateral deviation from plane of reference, right. | From center of impact, longitudinal. | | From center of impact, lateral. | |
|---|---|---|---|---|---|---|
| | | | + | − | Right. | Left. |
| | *Yards.* | *Yards.* | *Yds.* | *Yds.* | *Yards.* | *Yds.* |
| 126 | 323 | 3 | 12.4 | | | 1 |
| 127 | 252 | 3 | | 58.6 | | 1 |
| 128 | 300 | 6 | | 10.6 | 2 | |
| 129 | 324 | 4 | 13.4 | | | |
| 130 | 354 | 4 | 43.4 | | | |
| | 1,553 | 20 | 69.2 | 69.2 | 2 | 2 |

| | *Yards.* |
|---|---|
| Mean range | 310.6 |
| Mean lateral deviation from plane of reference | 4 |
| Mean longitudinal deviation from center of impact | 27.68 |
| Mean lateral deviation from center of impact | 8 |

1,553 ÷ 5 = 310.6 20 ÷ 5 = 4 138.4 ÷ 5 = 27.68 4 ÷ 5 = 0.80

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1, Watervliet*

| Date. | | No. of fire. | Powder. | | Projectile. | | Elevation. | Time of flight. | Recoil |
|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1890. | | | | *Ounces.* | | *Lbs. Oz.* | ° ′ | *Secs.* | *Ft. In.* |
| Sept. 9 | ............ | 131 | Du Pont's I. K. H. Lot 1. Density, 1.725. Granulation, 2,050. | 3¼ | Shell (banded), experimental. Lot 249. | 19 3<br>13 sand.<br>20 0 | 15 00 | 5 | ........ |
| | | 132 | | 3¼ | | 19 3<br>13 sand.<br>20 0 | 15 00 | 5¼ | ........ |
| | | 133 | | 3¼ | | 19 4<br>12 sand.<br>20 0 | 15 00 | 5 | ....... |
| | | 134 | | 3¼ | | 19 4<br>12 sand.<br>20 0 | 15 00 | 5 | ....... |
| | | 135 | | 3¼ | | 19 6<br>10 sand.<br>20 0 | 15 00 | 5 | 4 [illegible] |

TARGET.

| No. of round. | Range. | Deviation right. |
|---|---|---|
| | *Yards.* | *Yards.* |
| 131................ | 389 | 13 |
| 132................ | 421 | 3 |
| 133................ | 397 | 4 |
| 134................ | 426 | 3 |
| 135................ | 397 | 3 |

| | *Yards.* |
|---|---|
| Greatest range.......................................... | [illegible] |
| Least range.......................................... | [illegible] |
| Dispersion in range.......................................... | [illegible] |
| Greatest deviation from plane of reference.............. | [illegible] |
| Least deviation from plane of reference.................. | [illegible] |
| Lateral dispersion.......................................... | [illegible] |

*Arsenal, at Sandy Hook, N. J., September 9, 1890*—Continued.

| Wind, strength and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|
| From front and left, 5 miles an hour. | Cannon friction primers (experimental), with modified priming, March, 1890.<br>Fired down the beach. Direction given by wooden strip nailed on platform. | Rope restraining recoil broke. |

TARGET.

| No. of round. | Range. | Lateral deviation from plane of reference, right. | From center of impact, longitudinal. | | From center of impact, lateral. | |
|---|---|---|---|---|---|---|
| | | | + | − | Right. | Left. |
| | *Yards.* | *Yards.* | *Yds.* | *Yds.* | *Yards.* | *Yds.* |
| 131 | 389 | 13 | ...... | 17 | 7.8 | ...... |
| 132 | 421 | 3 | 15 | ...... | ........ | 2.2 |
| 133 | 397 | 4 | ...... | 9 | ........ | 1.2 |
| 134 | 426 | 3 | 20 | ...... | ........ | 2.2 |
| 135 | 397 | 3 | ...... | 9 | ........ | 2.2 |
| | 2,030 | 26 | 35 | 35 | 7.8 | 7.8 |

| | *Yards.* |
|---|---|
| Mean range | 406 |
| Mean lateral deviation from plane of reference | 5.2 |
| Mean longitudinal deviation from center of impact | 14 |
| Mean lateral deviation from center of impact | 3.12 |

2,030 ÷ 5 = 406  26 ÷ 5 = 5.2  70 ÷ 5 = 14  15.6 ÷ 5 = 3.12

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1, Watervliet*

| Date. | | No. of fire. | Powder. | | Projectile. | | Elevation. | Time of flight. | Wind strength and direction. |
|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1890. | | | | *Ounces.* | | *Lbs. Oz.* | ° ′ | *Secs.* | |
| Sept. 9 | A. M.... | 136 | Du Pont's I. K. H. Lot 1. Density, 1.725. Granulation, 2,050. | 3½ | Shell (banded), experimental. Lot 249. | 19 2<br>14 sand.<br>20 0 | 45 00 | Lost. | From front and left, 5 miles an hour. |
| | | 137 | | 3½ | | 19 5<br>11 sand.<br>20 0 | 45 00 | 12 | |
| | | 138 | | 3½ | | 19 2<br>14 sand.<br>20 0 | 45 00 | 12½ | |
| | | 139 | | 3½ | | 19 0<br>1 0 sand.<br>20 0 | 45 00 | 12½ | |
| | | 140 | | 3½ | | 19 4<br>12 sand.<br>20 0 | 45 00 | 12½ | |

TARGET.

| No. of round. | Range. | Deviation right. |
|---|---|---|
| | *Yards.* | *Yards.* |
| 136 | 754 | 25 |
| 137 | 738 | 24 |
| 138 | 719 | 23 |
| 139 | 716 | 23 |
| 140 | 710 | 23 |

| | *Yards.* |
|---|---|
| Greatest range | 754 |
| Least range | 710 |
| Dispersion in range | 44 |
| Greatest deviation from plane of reference | 25 |
| Least deviation from plane of reference | 23 |
| Lateral dispersion | 2 |

*Arsenal, at Sandy Hook, N. J., September 9, 1890*—Continued.

| | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and meteorological data. |
|---|---|
| Cannon friction primers (experimental), with modified priming, March, 1890. | |
| | Rope restraining recoil broke. |
| Fired down the beach. Direction given by wooden strips nailed on platform. | |
| | First primer failed to ignite cartridge. |

## TARGET.

| No. of round. | Range. | Lateral deviation from plane of reference, right. | From center of impact, longitudinal. | | From center of impact, lateral. | |
|---|---|---|---|---|---|---|
| | | | + | − | Right. | Left. |
| | *Yards.* | *Yards.* | *Yds.* | *Yds.* | *Yards.* | *Yds.* |
| 136 | 754 | 25 | 26.6 | ...... | 1.4 | ...... |
| 137 | 738 | 24 | 10.6 | ...... | .4 | ...... |
| 138 | 719 | 23 | ...... | 8.4 | ........ | .6 |
| 139 | 716 | 23 | ...... | 11.4 | ........ | .6 |
| 140 | 710 | 23 | ...... | 17.4 | ........ | .6 |
| | 3,637 | 118 | 37.2 | 37.2 | 1.8 | 1.8 |

| | *Yards.* |
|---|---|
| Mean range | 727.4 |
| Mean lateral deviation from plane of reference | 23.6 |
| Mean longitudinal deviation from center of impact | 14.88 |
| Mean lateral deviation from center of impact | 72 |

3,637 + 5 = 727.4    118 + 5 = 23.6    74.4 + 5 = 14.88    3.6 + 5 = 0.72

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1, Watervliet*

| Date. | | No. of fire. | Powder. | | Projectile. | | Elevation. | Time of flight. | Wind strengt and direction. |
|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1890. | | | | *Ounces.* | | *Lbs. Oz.* | ° ′ | *Secs.* | |
| Sept. 9 | A. M.... | 141 | Du Pont's I. K. H. Lot 1. Density, 1.725. Granulation, 2,050. | 5 | Shell (banded), experimental. Lot 249. | 19 4<br>12 sand.<br>20 0 | 15 00 | 6 | From front and left, 6 miles an hour. |
| | | 142 | | 5 | | 19 4<br>12 sand.<br>20 0 | 15 00 | 6 | |
| | | 143 | | 5 | | 19 4<br>12 sand.<br>20 0 | 15 00 | 6 | |
| | | 144 | | 5 | | 19 3<br>13 sand.<br>20 0 | 15 00 | 5½ | |
| | | 145 | | 5 | | 19 3<br>13 sand.<br>20 0 | 15 00 | 6 | |

TARGET.

| No. of round. | Range. | Deviation right. |
|---|---|---|
| | *Yards.* | *Yards.* |
| 141 | 568 | 3 |
| 142 | 560 | 3 |
| 143 | 558 | 1 |
| 144 | 558 | 3 |
| 145 | 553 | 6 |

| | *Yards* |
|---|---|
| Greatest range | 56 |
| Least range | 55 |
| Dispersion in range | 15 |
| Greatest deviation from plane of reference | 6 |
| Least deviation from plane of reference | 1 |
| Lateral dispersion | 5 |

*Arsenal, at Sandy Hook, N. J., September 9, 1890*—Continued.

| | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and meteorological data. |
|---|---|
| Cannon friction primers (experimental), with modified priming, March, 1890. | |
| Fired down the beach. Direction given by wooden strip nailed on platform. | First primer failed to ignite cartridge. |

TARGET.

| No. of round. | Range. | Lateral deviation from plane of reference, right. | From center of impact, longitudinal. | | From center of impact, lateral. | |
|---|---|---|---|---|---|---|
| | | | + | − | Right. | Left. |
| | *Yards.* | *Yards.* | *Yds.* | *Yds.* | *Yards.* | *Yds.* |
| 141 | 568 | 3 | 8.6 | ...... | ........ | .2 |
| 142 | 560 | 3 | .6 | ...... | ........ | .2 |
| 143 | 558 | 1 | ...... | 1.4 | ........ | 2.2 |
| 144 | 558 | 3 | ...... | 1.4 | ........ | .2 |
| 145 | 553 | 6 | ...... | 6.4 | 2.8 | ...... |
| | 2,797 | 16 | 9.2 | 9.2 | 2.8 | 2.8 |

| | *Yards.* |
|---|---|
| Mean range | 559.4 |
| Mean lateral deviation from plane of reference | 3.2 |
| Mean longitudinal deviation from center of impact | 3.68 |
| Mean lateral deviation from center of impact | 1.12 |

2,797 + 5 = 559.4 16 + 5 = 3.2 18.4 + 5 = 3.68 5.6 + 5 = 1.12

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1.*

| Date. | | No. of fire. | Powder. | | Projectile. | | Elevation. | Time of flight. | Recoil. |
|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1890. | | | | *Ounces.* | | *Lbs.* *Oz.* | ° ′ | *Secs.* | *Inches* |
| Sept. 22 | P. M.... | 146 | Du Pont's I. K. H. Lot 1. Density, 1.725. Granulation, 2.050. | 3 | Shell (banded), experimental. Lot 249. | 19 2<br>14 sand.<br>20 0 | 15 00 | 3½ | [illegible] |
| | | 147 | | 3 | | 18 15<br>1 1 sand.<br>20 0 | 15 00 | 3½ | [illegible] |
| | | 148 | | 3 | | 19 12<br>4 sand.<br>20 0 | 15 00 | 4 | [illegible] |
| | | 149 | | 3 | | 19 4<br>12 sand.<br>20 0 | 15 00 | 4 | [illegible] |
| | | 150 | | 3 | | 19 4<br>12 sand.<br>20 0 | 15 00 | 4¾ | [illegible] |
| | | 151 | | 3 | | 20 0 natural weight. | 15 00 | 4½ | [illegible] |

TARGET.

| No. of round. | Range. | Deviation, right. |
|---|---|---|
| | *Yards.* | *Yards.* |
| 147 | 269 | 3 |
| 148 | 290 | 3 |
| 149 | 285 | 3 |
| 150 | 332 | 4 |
| 151 | 300 | 3 |

| | *Yards.* |
|---|---|
| Greatest range | [illegible] |
| Least range | [illegible] |
| Dispersion in range | [illegible] |
| Greatest deviation from plane of reference | 4 |
| Least deviation from plane of reference | 3 |
| Lateral dispersion | 1 |

*Watervliet Arsenal, at Sandy Hook, N. J., September 22, 1890.*

| Wind, strength and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|
| From right, 10 miles an hour. | Mortar mounted on new experimental carriage made at Watervliet Arsenal. Cannon friction primers (experimental), with modified priming, March, 1890. | Sighting shot. |
| | Fired from wooden platform of 4-inch plank 14 feet long. Recoil restrained by 5-inch rope fastened to round post 10 feet in front of platform and attached to bight of rope spliced through loops of carriage.<br>Fired down the beach. | Two primers failed to ignite cartridge.<br>First primer failed; defective. Friction composition in short tube ignited, but failed to ignite rifle powder in long tube. |

TARGET.

| No. of round. | Range. | Lateral deviation from plane of reference, right. | From center of impact, longitudinal. | | From center of impact, lateral. | |
|---|---|---|---|---|---|---|
| | | | + | − | Right. | Left. |
| | *Yards.* | *Yards.* | *Yds.* | *Yds.* | *Yards.* | *Yds.* |
| 147 | 269 | 3 | | 26.2 | | .2 |
| 148 | 290 | 3 | | 5.2 | | .2 |
| 149 | 285 | 3 | | 10.2 | | .2 |
| 150 | 332 | 4 | 36.8 | | .8 | |
| 151 | 300 | 3 | 4.8 | | | .2 |
| | 1,476 | 16 | 41.6 | 41.6 | .8 | .8 |

| | *Yards.* |
|---|---|
| Mean range | 295.2 |
| Mean lateral deviation from plane of reference | 3.2 |
| Mean longitudinal deviation from center of impact | 16.64 |
| Mean lateral deviation from center of impact | 32 |

1,476+5=295.2 16+5=3.2 83.2+5=16.64 16+5=0.32

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1.*

**[Object of firing, to determine range**

| Date. | | No. of fire. | Powder. | | Projectile. | | Elevation. | Recoil. | Wind strength and direction. |
|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1890. | | | | *Ounces.* | | *Lbs. Oz.* | ° ′ | *Inches.* | |
| Sept. 9 | A. M ..... | 126 | Du Pont's I. K. H. Lot 1. Density, 1.725. Granulation, 2,050. | 3 | Shell (banded), experimental. Lot 249. | 19 1<br>15 sand.<br>20 0 | 15 00 | 7 | From front and left, 5 miles an hour. |
| | | 127 | | 3 | | 19 2<br>14 sand.<br>20 0 | 15 00 | 3¼ | |
| | | 128 | | 3 | | 19 2<br>14 sand.<br>20 0 | 15 00 | 1 | |
| | | 129 | | 3 | | 19 4<br>12 sand.<br>20 0 | 15 00 | ........ | |
| | | 130 | | 3 | | 19 4<br>12 sand.<br>20 0 | 15 00 | ........ | |

TARGET.

| No. of round. | Range. | Deviation, right. |
|---|---|---|
| | *Yards.* | *Yards.* |
| 126 | 323 | 3 |
| 127 | 252 | 3 |
| 128 | 300 | 6 |
| 129 | 324 | 4 |
| 130 | 354 | 4 |

| | *Yards* |
|---|---|
| Greatest range | 354 |
| Least range | 252 |
| Dispersion in range | 102 |
| Greatest deviation from plane of reference | 6 |
| Least deviation from plane of reference | 3 |
| Lateral dispersion | 3 |

*Watervliet Arsenal, at Sandy Hook, N. J., September 9, 1890.*

corresponding to charge of powder.]

| Time of flight. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|
| | Mortar mounted on new experimental carriage. Cannon friction primers (experimental), with modified priming, March, 1890. | |
| *Secs.*<br>4½ | Fired from wooden platform of 4-inch plank 14 feet long.<br>Recoil restrained by a 5-inch rope fastened to round post 10 feet in front of platform and attached to bight of rope spliced through loops of carriage.<br>Fired down the beach.<br>Direction given by wooden strip nailed on platform. | First primer failed to ingnite cartridge. |
| 4¾ | | |
| 4¾ | | |
| 4½ | | |
| 4½ | | |

TARGET.

| No. of round. | Range. | Lateral deviation from plane of reference, right. | From center of impact, longitudinal. | | From center of impact, lateral. | |
|---|---|---|---|---|---|---|
| | | | + | − | Right. | Left. |
| | *Yards.* | *Yards.* | *Yds.* | *Yds.* | *Yards.* | *Yds.* |
| 126 | 323 | 3 | 12.4 | ...... | ........ | 1 |
| 127 | 252 | 3 | ...... | 58.6 | ........ | 1 |
| 128 | 300 | 6 | ...... | 10.6 | 2 | ...... |
| 129 | 324 | 4 | 13.4 | ...... | ........ | ...... |
| 130 | 354 | 4 | 43.4 | ...... | ........ | ...... |
| | 1,553 | 20 | 69.2 | 69.2 | 2 | 2 |

| | *Yards.* |
|---|---|
| Mean range | 310.6 |
| Mean lateral deviation from plane of reference | 4 |
| Mean longitudinal deviation from center of impact | 27.68 |
| Mean lateral deviation from center of impact | 8 |

1,553 ÷ 5 = 310.6   20 ÷ 5 = 4   138.4 ÷ 5 = 27.68   4 ÷ 5 = 0.80

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1, Watervliet*

| Date. | | No. of fire. | Powder. | | Projectile. | | Elevation. | Time of flight. | Recoi |
|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1890. | | | | *Ounces.* | | *Lbs. Oz.* | ° ′ | *Secs.* | *Ft. In.* |
| Sept. 9 | ............ | 131 | Du Pont's I. K. H. Lot 1. Density, 1.725. Granulation, 2,050. | 3⅛ | Shell (banded), experimental. Lot 249. | 19 3<br>13 sand.<br>20 0 | 15 00 | 5 | ........ |
| | | 132 | | 3⅛ | | 19 3<br>13 sand.<br>20 0 | 15 00 | 5½ | ...... |
| | | 133 | | 3⅛ | | 19 4<br>12 sand.<br>20 0 | 15 00 | 5 | ....... |
| | | 134 | | 3⅛ | | 19 4<br>12 sand.<br>20 0 | 15 00 | 5 | ....... |
| | | 135 | | 3⅛ | | 19 6<br>10 sand.<br>20 0 | 15 00 | 5 | 4 [illegible] |

TARGET.

| No. of round. | Range. | Deviation right. |
|---|---|---|
| | *Yards.* | *Yards.* |
| 131................ | 389 | 13 |
| 132................ | 421 | 3 |
| 133................ | 397 | 4 |
| 134................ | 426 | 3 |
| 135................ | 397 | 3 |

| | *Yards.* |
|---|---|
| Greatest range .......................................... | [illegible] |
| Least range .............................................. | [illegible] |
| Dispersion in range .............................. | [illegible] |
| Greatest deviation from plane of reference ............. | 13 |
| Least deviation from plane of reference ................. | 3 |
| Lateral dispersion .................................. | 10 |

*Arsenal, at Sandy Hook, N. J., September 9, 1890*—Continued.

| Wind, strength and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|
| From front and left, 5 miles an hour. | Cannon friction primers (experimental), with modified priming, March, 1890.<br>Fired down the beach. Direction given by wooden strip nailed on platform. | Rope restraining recoil broke. |

TARGET.

| No. of round. | Range. | Lateral deviation from plane of reference, right. | From center of impact, longitudinal. | | From center of impact, lateral. | |
|---|---|---|---|---|---|---|
| | | | + | − | Right. | Left. |
| | *Yards.* | *Yards.* | *Yds.* | *Yds.* | *Yards.* | *Yds.* |
| 131 | 389 | 13 | ...... | 17 | 7.8 | ...... |
| 132 | 421 | 3 | 15 | ...... | ........ | 2.2 |
| 133 | 397 | 4 | ...... | 9 | ........ | 1.2 |
| 134 | 426 | 3 | 20 | ...... | ........ | 2.2 |
| 135 | 397 | 3 | ...... | 9 | ........ | 2.2 |
| | 2,030 | 26 | 35 | 35 | 7.8 | 7.8 |

| | *Yards.* |
|---|---|
| Mean range | 406 |
| Mean lateral deviation from plane of reference | 5.2 |
| Mean longitudinal deviation from center of impact | 14 |
| Mean lateral deviation from center of impact | 3.12 |

2,030 ÷5=406     26+5=5.2     70+5=14     15.6+5=3.12

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1, Watervliet*

| Date. | | No. of fire. | Powder. | | Projectile. | | Elevation. | Time of flight. | Wind strength and direction. |
|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1890. | | | | *Ounces.* | | *Lbs. Oz.* | ° ′ | *Secs.* | |
| Sept. 9 | A. M.... | 136 | Du Pont's I. K. H. Lot 1. Density, 1.725. Granulation, 2,050. | 3½ | Shell (banded), experimental. Lot 249. | 19 2<br>14 sand.<br>20 0 | 45 00 | Lost. | From front and left, 6 miles an hour. |
| | | 137 | | 3½ | | 19 5<br>11 sand.<br>20 0 | 45 00 | 12 | |
| | | 138 | | 3½ | | 19 2<br>14 sand.<br>20 0 | 45 00 | 12½ | |
| | | 139 | | 3½ | | 19 0<br>1 0 sand.<br>20 0 | 45 00 | 12½ | |
| | | 140 | | 3½ | | 19 4<br>12 sand.<br>20 0 | 45 00 | 12½ | |

TARGET.

| No. of round. | Range. | Deviation right. |
|---|---|---|
| | *Yards.* | *Yards.* |
| 136 | 754 | 25 |
| 137 | 728 | 24 |
| 138 | 719 | 23 |
| 139 | 716 | 23 |
| 140 | 710 | 23 |

| | *Yards.* |
|---|---|
| Greatest range | 754 |
| Least range | 710 |
| Dispersion in range | 44 |
| Greatest deviation from plane of reference | 25 |
| Least deviation from plane of reference | 23 |
| Lateral dispersion | 2 |

*Arsenal, at Sandy Hook, N. J., September 9, 1890*—Continued.

| | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|
| Cannon friction primers (experimental), with modified priming, March, 1890. | |
| Fired down the beach. Direction given by wooden strips nailed on platform. | Rope restraining recoil broke.<br>First primer failed to ignite cartridge. |

TARGET.

| No. of round. | Range. | Lateral deviation from plane of reference, right. | From center of impact, longitudinal. | | From center of impact, lateral. | |
|---|---|---|---|---|---|---|
| | | | + | − | Right. | Left. |
| | *Yards.* | *Yards.* | *Yds.* | *Yds.* | *Yards.* | *Yds.* |
| 136 | 754 | 25 | 26.6 | ...... | 1.4 | ...... |
| 137 | 738 | 24 | 10.6 | ...... | .4 | ...... |
| 138 | 719 | 23 | ...... | 8.4 | ........ | .6 |
| 139 | 716 | 23 | ...... | 11.4 | ........ | .6 |
| 140 | 710 | 23 | ...... | 17.4 | ........ | .6 |
| | 3,637 | 118 | 37.2 | 37.2 | 1.8 | 1.8 |

| | *Yards.* |
|---|---|
| Mean range | 727.4 |
| Mean lateral deviation from plane of reference | 23.6 |
| Mean longitudinal deviation from center of impact | 14.88 |
| Mean lateral deviation from center of impact | 72 |

3,637 + 5 = 727.4 118 + 5 = 23.6 74.4 + 5 = 14.88 3.6 + 5 = 0.72

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1, Watervliet*

| Date. | | No. of fire. | Powder. | | Projectile. | | Elevation. | Time of flight. | Wind strength and direction. |
|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1890. | | | | *Ounces.* | | *Lbs. Oz.* | ° ' | *Secs.* | |
| Sept. 9 | A. M.... | 141 | Du Pont's I. K. H. Lot 1. Density, 1.725. Granulation, 2,050. | 5 | Shell (banded), experimental. Lot 249. | 19 4<br>12 sand.<br>20 0 | 15 00 | 6 | From front and left, 5 miles an hour. |
| | | 142 | | 5 | | 19 4<br>12 sand.<br>20 0 | 15 00 | 6 | |
| | | 143 | | 5 | | 19 4<br>12 sand.<br>20 0 | 15 00 | 6 | |
| | | 144 | | 5 | | 19 3<br>13 sand.<br>20 0 | 15 00 | 5½ | |
| | | 145 | | 5 | | 19 3<br>13 sand.<br>20 0 | 15 00 | 6 | |

TARGET.

| No. of round. | Range. | Deviation right. |
|---|---|---|
| | *Yards.* | *Yards.* |
| 141 | 568 | 3 |
| 142 | 560 | 3 |
| 143 | 558 | 1 |
| 144 | 558 | 3 |
| 145 | 553 | 6 |

| | *Yard* |
|---|---|
| Greatest range | 56 |
| Least range | 55 |
| Dispersion in range | 15 |
| Greatest deviation from plane of reference | 6 |
| Least deviation from plane of reference | 1 |
| Lateral dispersion | 5 |

*Arsenal, at Sandy Hook, N. J., September 9, 1890*—Continued.

| | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|
| Cannon friction primers (experimental), with modified priming, March, 1890. | |
| Fired down the beach. Direction given by wooden strip nailed on platform. | First primer failed to ignite cartridge. |

TARGET.

| No. of round. | Range. | Lateral deviation from plane of reference, right. | From center of impact, longitudinal. | | From center of impact, lateral. | |
|---|---|---|---|---|---|---|
| | | | + | − | Right. | Left. |
| | *Yards.* | *Yards.* | *Yds.* | *Yds.* | *Yards.* | *Yds.* |
| 141 | 568 | 3 | 8.6 | ...... | ........ | .2 |
| 142 | 560 | 3 | .6 | ...... | ........ | .2 |
| 143 | 558 | 1 | ...... | 1.4 | ........ | 2.2 |
| 144 | 558 | 3 | ...... | 1.4 | ........ | .2 |
| 145 | 553 | 6 | ...... | 6.4 | 2.8 | ...... |
| | 2,797 | 16 | 9.2 | 9.2 | 2.8 | 2.8 |

| | *Yards.* |
|---|---|
| Mean range | 559.4 |
| Mean lateral deviation from plane of reference | 3.2 |
| Mean longitudinal deviation from center of impact | 3.68 |
| Mean lateral deviation from center of impact | 1.12 |

2,797 + 5 = 559.4      16 + 5 = 3.2      18.4 + 5 = 3.68      5.6 + 5 = 1.12

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1.*

| Date. | | No. of fire. | Powder. | | Projectile. | | Elevation. | Time of flight. | Recoil |
|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1890. | | | | *Ounces.* | | *Lbs. Oz.* | ° ′ | *Secs.* | *Inches* |
| Sept. 22 | P. M.... | 146 | Du Pont's I. K. H. Lot 1. Density, 1.725. Granulation, 2.050. | 3 | Shell (banded), experimental. Lot 249. | 19 2<br>14 sand.<br>20 0 | 15 00 | 3¼ | [illegible] |
| | | 147 | | 3 | | 18 15<br>1 1 sand.<br>20 0 | 15 00 | 3½ | [illegible] |
| | | 148 | | 3 | | 19 12<br>4 sand.<br>20 0 | 15 00 | 4 | [illegible] |
| | | 149 | | 3 | | 19 4<br>12 sand.<br>20 0 | 15 00 | 4 | [illegible] |
| | | 150 | | 3 | | 19 4<br>12 sand.<br>20 0 | 15 00 | 4¾ | [illegible] |
| | | 151 | | 3 | | 20 0 natural weight. | 15 00 | 4¼ | [illegible] |

TARGET.

| No. of round. | Range. | Deviation, right. |
|---|---|---|
| | *Yards.* | *Yards.* |
| 147 | 269 | 3 |
| 148 | 290 | 3 |
| 149 | 285 | 3 |
| 150 | 332 | 4 |
| 151 | 300 | 3 |

| | *Yards.* |
|---|---|
| Greatest range | [illegible] |
| Least range | [illegible] |
| Dispersion in range | [illegible] |
| Greatest deviation from plane of reference | 4 |
| Least deviation from plane of reference | 3 |
| Lateral dispersion | 1 |

*Watervliet Arsenal, at Sandy Hook, N. J., September 22, 1890.*

| Wind, strength and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|
| From right, 10 miles an hour. | Mortar mounted on new experimental carriage made at Watervliet Arsenal. Cannon friction primers (experimental), with modified priming, March, 1890. | |
| | | Sighting shot. |
| | Fired from wooden platform of 4-inch plank 14 feet long. Recoil restrained by 5-inch rope fastened to round post 10 feet in front of platform and attached to bight of rope spliced through loops of carriage.<br>Fired down the beach. | Two primers failed to ignite cartridge. |
| | | First primer failed; defective. Friction composition in short tube ignited, but failed to ignite rifle powder in long tube. |

TARGET.

| No. of round. | Range. | Lateral deviation from plane of reference, right. | From center of impact, longitudinal. | | From center of impact, lateral. | |
|---|---|---|---|---|---|---|
| | | | + | — | Right. | Left. |
| | *Yards.* | *Yards.* | *Yds.* | *Yds.* | *Yards.* | *Yds.* |
| 147 | 269 | 3 | ...... | 26.2 | ........ | .2 |
| 148 | 290 | 3 | ...... | 5.2 | ........ | .2 |
| 149 | 285 | 3 | ...... | 10.2 | ........ | .2 |
| 150 | 332 | 4 | 36.8 | ...... | .8 | ...... |
| 151 | 300 | 3 | 4.8 | ...... | ........ | .2 |
| | 1,476 | 16 | 41.6 | 41.6 | .8 | .8 |

| | *Yards.* |
|---|---|
| Mean range | 295.2 |
| Mean lateral deviation from plane of reference | 3.2 |
| Mean longitudinal deviation from center of impact | 16.64 |
| Mean lateral deviation from center of impact | 32 |

1,476÷5 = 295.2    16÷5 = 3.2    83.2÷5 = 16.64    16÷5 = 0.32

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1, Watervliet*

| Date. | | No. of fire. | Powder. | | Projectile. | | Elevation. | Time of flight. | Recoil. |
|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1890. | | | | *Ounces.* | | *Lbs. Oz.* | ° ′ | *Secs.* | *Inches* |
| Sept. 22 | P. M...... | 152 | Du Pont's I. K. H. Lot 1. Density, 1.725. Granulation, 2,050. | 3 | Shell (banded), experimental. Lot 249. | 19 6<br>10 sand.<br>20 0 | 45 00 | 11⅛ | 2 |
| | | 153 | | 3 | | 19 0<br>1 0 sand.<br>20 0 | 45 00 | 11⅛ | 2 |
| | | 154 | | 3 | | 19 13<br>3 sand.<br>20 0 | 45 00 | 10⅞ | 2 |
| | | 155 | | 3 | | 19 3<br>13 sand.<br>20 0 | 45 00 | 11⅛ | 2 |
| | | 156 | | 3 | | 19 2<br>14 sand.<br>20 0 | 45 00 | 11⅛ | 2 |

TARGET.

| No. of round. | Range. | Deviation, right. |
|---|---|---|
| | *Yards.* | *Yards.* |
| 152 | 578 | 23 |
| 153 | 574 | 24 |
| 154 | 540 | 22 |
| 155 | 577 | 22 |
| 156 | 561 | 21 |

| | *Yards.* |
|---|---|
| Greatest range | 578 |
| Least range | 540 |
| Dispersion in range | 38 |
| Greatest deviation from plane of reference | 24 |
| Least deviation from plane of reference | 21 |
| Lateral dispersion | 3 |

*Arsenal, at Sandy Hook, N. J., September 22, 1890*—Continued.

| Wind, strength and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|
| | Cannon friction primers (experimental), with modified priming, March, 1890. | |
| From right, 10 miles an hour. | Fired down the beach. | First primer failed; defective. Composition in short tube ignited, but failed to ignite rifle powder in long tube.<br>First primer pulled out and broken. |

TARGET.

| No. of round. | Range. | Lateral deviation from plane of reference, right. | From center of impact, longitudinal. | | From center of impact, lateral. | |
|---|---|---|---|---|---|---|
| | | | + | − | Right. | Left. |
| | *Yards.* | *Yards.* | *Yds.* | *Yds.* | *Yards.* | *Yds.* |
| 152 | 578 | 23 | 12 | ...... | .6 | ...... |
| 153 | 574 | 24 | 8 | ...... | 1.6 | ...... |
| 154 | 540 | 22 | ...... | 26 | ........ | .4 |
| 155 | 577 | 22 | 11 | ...... | ........ | .4 |
| 156 | 561 | 21 | ...... | 5 | ........ | 1.4 |
| | 2,830 | 112 | 31 | 31 | 2.2 | 2.2 |

| | *Yards.* |
|---|---|
| Mean range | 566 |
| Mean lateral deviation from plane of reference | 22.4 |
| Mean longitudinal deviation from center of impact | 12.4 |
| Mean lateral deviation from center of impact | 88 |

2,830÷5=566 112÷5=22.4 62÷5=12.4 4.4÷5=0.88

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1, Watervliet*

| Date. | | No. of fire. | Powder. | | Projectile. | | Elevation. | Time of flight. | Recoil. |
|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1890. | | | | *Ounces.* | | *Lbs. Oz.* | ° ′ | *Secs.* | *Inches.* |
| Sept. 22 | P. M...... | 157 | Du Pont's I. K. H. Lot 1. Density, 1.725. Granulation, 2,050. | 5 | Shell (banded), experimental. Lot 249. | 19 4<br>12 sand.<br>20 0 | 45 00 | 15 | 2 |
| | | 158 | | 5 | | 19 3<br>13 sand.<br>20 0 | 45 00 | 14⅓ | 2 |
| | | 159 | | 5 | | 18 1<br>1 15 sand.<br>20 0 | 45 00 | 14⅓ | 2 |
| | | 160 | | 5 | | 19 3<br>13 sand.<br>20 0 | 45 00 | 14 | 2 |
| | | 161 | | 5 | | 19 2<br>14 sand.<br>20 0 | 45 00 | 14⅓ | 2 |

TARGET.

| No. of round. | Range. | Deviation, right. |
|---|---|---|
| | *Yards.* | *Yards.* |
| 157 | 993 | 36 |
| 158 | 950 | 31 |
| 159 | 1,023 | 34 |
| 160 | 967 | 32 |
| 161 | 1,001 | 34 |

| | *Yards.* |
|---|---|
| Greatest range | 1,023 |
| Least range | 950 |
| Dispersion in range | 73 |
| Greatest deviation from plane of reference | 36 |
| Least deviation from plane of reference | 31 |
| Lateral dispersion | 5 |

*Arsenal, at Sandy Hook, N. J., September 22, 1890*—Continued.

| Wind, strength and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|
| From right, 10 miles an hour. | Cannon friction primers (experimental), with modified priming, March, 1890.<br>Fired down the beach.<br>Stop watch held by Sergt. R. Johnston, O. D. | |

TARGET.

| No. of round. | Range. | Lateral deviation from plane of reference, right. | From center of impact, longitudinal. | | From center of impact, lateral. | |
|---|---|---|---|---|---|---|
| | | | + | − | Right. | Left. |
| | *Yards.* | *Yards.* | *Yds.* | *Yds.* | *Yards.* | *Yds.* |
| 157 | 993 | 36 | 6.2 | ...... | 2.6 | ...... |
| 158 | 950 | 31 | ...... | 36.8 | ........ | 2.4 |
| 159 | 1,023 | 34 | 36.2 | ...... | .6 | ...... |
| 160 | 967 | 32 | ...... | 19.8 | ........ | 1.4 |
| 161 | 1,001 | 34 | 14.2 | ...... | .6 | ...... |
| | 4,934 | 167 | 56.6 | 56.6 | 3.8 | 3.8 |

| | *Yards.* |
|---|---|
| Mean range | 986.8 |
| Mean lateral deviation from plane of reference | 33.4 |
| Mean longitudinal deviation from center of impact | 22.64 |
| Mean lateral deviation from center of impact | 1.52 |

4934+5=986.8 167+5=33.4 113.2+5=22.64 7.6+5=1.52

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1, Watervliet*

| Date. | | No. of fire. | Powder. | | Projectile. | | Elevation. | Time of flight. | Recoil. |
|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1890. | | | | *Ounces.* | | *Lbs. Oz.* | ° ′ | *Secs.* | *Inches.* |
| Sept. 22 | P. M...... | 162 | Du Pont's I. K. H. Lot 1. Density, 1.725. Granulation, 2,050. | 8 | Shell (banded), experimental. Lot 249. | 19 3 sand.<br>13<br>20 0 | 15 00 | 10½ | 2 |
| | | 163 | | 8 | | 19 3<br>13 sand.<br>20 0 | 15 00 | 10 | 2 |
| | | 164 | | 8 | | 18 1<br>1 15 sand.<br>20 0 | 15 00 | 8½ | 2 |
| | | 165 | | 8 | | 18 14<br>1 2 sand.<br>20 0 | 15 00 | 8 | 2 |
| | | 166 | | 8 | | 19 8½<br>7½ sand.<br>20 0 | 15 00 | 8 | 2 |

## TARGET.

| No. of round. | Range. | Deviation, right. |
|---|---|---|
| | *Yards.* | *Yards.* |
| 162 | 904 | 12 |
| 163 | 869 | 10 |
| 164 | 900 | 13 |
| 165 | 897 | 13 |
| 166 | 841 | 12 |

| | *Yards.* |
|---|---|
| Greatest range | 904 |
| Least range | 841 |
| Dispersion in range | 63 |
| Greatest deviation from plane of reference | 13 |
| Least deviation from plane of reference | 10 |
| Lateral dispersion | |

*Arsenal, at Sandy Hook, N. J., September 22, 1890*—Continued.

| Wind, strength and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|
| | Cannon friction primers (experimental), with modified priming, March, 1890. | |
| From right, 10 miles an hour. | Fired down the beach. | |
| | Stop watch held by Sergt. R. Johnston, O. D. Mortar sighted by Lieut. O. M. Lissak, O. D. Fall of projectile observed by Sergt. R. Johnston, O. D. Firing conducted by Lieut. O. M. Lissak, O. D. | |

TARGET.

| No, of round. | Range. | Lateral deviation from plane of reference, right. | From center of impact, longitudinal. | | From center of impact, lateral. | |
|---|---|---|---|---|---|---|
| | | | + | – | Right. | Left. |
| | *Yards.* | *Yards.* | *Yds.* | *Yds.* | *Yards.* | *Yds.* |
| 162 | 904 | 12 | 21.8 | ...... | ...... | ...... |
| 163 | 869 | 10 | ...... | 13.2 | ...... | 2 |
| 164 | 900 | 18 | 17.8 | ...... | 1 | ...... |
| 165 | 897 | 13 | 14.8 | ...... | 1 | ...... |
| 166 | 841 | 12 | ...... | 41.2 | ...... | ...... |
| | 4,411 | 60 | 54.4 | 54.4 | 2 | 2 |

| | *Yards.* |
|---|---|
| Mean range | 882.2 |
| Mean lateral deviation from plane of reference | 12.00 |
| Mean longitudinal deviation from center of impact | 21.76 |
| Mean lateral deviation from center of impact | 8 |

4,411+5=882.2 60+5=12 108.8+5=21.76 4+5=0.8

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1.*

[Object of firing, to determine range

| Date. | | No. of fire. | Powder. | | Projectile. | | Elevation. | Time of flight. | Recoil |
|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1890. | | | | *Ounces.* | | *Lbs. Oz.* | ° ′ | *Secs.* | *Inches.* |
| Oct. 30 | A. M. | 167 | Du Pont's I. K. H. Lot 1. Density, 1.725. Granulation, 2,050. | 11 | Shell (banded), experimental. Lot 249. | 19 4<br>12 sand.<br>20 0 | 15 00 | 9 | 5 |
| | | 168 | | 11 | | 18 13<br>1 3 sand.<br>20 0 | 15 00 | 9 | ... |
| | | 169 | | 11 | | 19 4<br>12 sand.<br>20 0 | 15 00 | 9½ | ....... |
| | | 170 | | 11 | | 19 3<br>13 sand.<br>20 0 | 15 00 | 8½ | 4 |
| | | 171 | | 11 | | 18 14<br>1 2 sand.<br>20 0 | 15 00 | 9 | *Feet.*<br>1 |
| | | 172 | | 11 | | 19 4<br>12<br>20 0 | 15 00 | 9½ | ...... |

TARGET.

| Number of rounds. | Range. | Deviation, right. |
|---|---|---|
| | *Yards.* | *Yards.* |
| 168 | 1,249 | 13 |
| 169 | 1,389 | 23 |
| 170 | 1,214 | 12 |
| 171 | 1,269 | 12 |
| 172 | 1,274 | 10 |

| | *Yards.* |
|---|---|
| Greatest range | 1,389 |
| Least range | 1,214 |
| Dispersion in range | 175 |
| Greatest deviation from plane of reference | 23 |
| Least deviation from plane of reference | 10 |
| Lateral dispersion | 13 |

*Watervliet Arsenal, at Sandy Hook, N. J., October 30, 1890.*

corresponding to charge of powder.]

| Wind, strength and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|
| From right, 18 miles an hour. | Mortar mounted on new (experimental) mortar carriage made at Watervliet Arsenal. Cannon friction primers (experimental), with modified priming, March, 1890. | Sighting shot; range, 1,178 yards; deviation to right, 10 yards. |
| | Fired down the beach. Aimed at center of 1-mile target.<br>Fired from wooden platform of 4-inch plank 14 feet long. Recoil restrained by 5-inch rope fastened to round post 10 feet in front of platform and attached to bight of rope spliced through loops of carriage. | First primer failed; bent and broken. |
| | | Rope restraining recoil removed. Mortar recoiled off platform. Wires of primer pulled out. |
| | | Rope replaced. |

TARGET.

| Number of round. | Range. | Lateral deviation from plane of reference, right. | From center of impact, longitudinal. | | From center of impact, lateral. | |
|---|---|---|---|---|---|---|
| | | | + | − | Right. | Left. |
| | *Yards.* | *Yards.* | *Yds.* | *Yds.* | *Yards.* | *Yds.* |
| 168 | 1,249 | 13 | ...... | 80 | ........ | 1 |
| 169 | 1,389 | 23 | 110 | ...... | 9 | ...... |
| 170 | 1,214 | 12 | ...... | 65 | ........ | 2 |
| 171 | 1,269 | 12 | ...... | 10 | ........ | 2 |
| 172 | 1,274 | 10 | ...... | 5 | ........ | 4 |
| | 6,395 | 70 | 110 | 110 | 9 | 9 |

| | *Yards.* |
|---|---|
| Mean range | 1,279 |
| Mean lateral deviation from plane of reference | 14 |
| Mean longitudinal deviation from center of impact | 44 |
| Mean lateral deviation from center of impact | 3.6 |

6,395+5=1,279 70+5=14 220+5=44 18+5=3.6

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1, Watervliet*

| Date. | | No. of fire. | Powder. | | Projectile. | | Elevation. | Time of flight. | Recoil. |
|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1890. | | | | *Ounces.* | | *Lbs. Oz.* | ° ′ | *Secs.* | *Inches.* |
| Oct. 30 | A.M...... | 173 | Du Pont's I. K. H. Lot 1. Density, 1.725. Granulation, 2,050. | 8 | Shell (banded), experimental. Lot 249. | 19 0<br>1 0 sand.<br>20 0 | 45 00 | Lost. | [illegible] |
| | | 174 | | 8 | | 19 8<br>13 sand.<br>20 0 | 45 00 | 20 | 6 |
| | | 175 | | 8 | | 19 2<br>14 sand.<br>20 0 | 45 00 | 19 | 6 |
| | | 176 | | 8 | | 19 5<br>11 sand.<br>20 0 | 45 00 | Lost. | 6 |
| | | 177 | | 8 | | 19 0<br>1 0 sand.<br>20 0 | 45 00 | 18 | ...... |

TARGET.

| No. of round. | Range. | Deviation, right. |
|---|---|---|
| | *Yards.* | *Yards.* |
| 173.................. | 1,849 | 50 |
| 174.................. | 1,760 | 54 |
| 175.................. | 1,700 | 56 |
| 176.................. | 1,513 | 52 |
| 177.................. | 1,623 | 54 |

| | *Yards* |
|---|---|
| Greatest range .................................... | 1 [illegible] |
| Least range .................................... | 1 [illegible] |
| Dispersion in range .................................... | [illegible] |
| Greatest deviation from plane of reference ........... | [illegible] |
| Least deviation from plane of reference ............. | [illegible] |
| Lateral dispersion .................................... | 6 |

*Arsenal, at Sandy Hook, N. J., October 30, 1890*—Continued.

| Wind, strength and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|
| From right. 18 miles an hour. | Cannon friction primers (experimental), with modified priming, March, 1890. | Primer failed; wire pulled out. |
| | Fired down the beach. Aimed at center of 1-mile target. | Elevation after fire, 67° 30′. |

TARGET.

| No. of round. | Range. | Lateral deviation from plane of reference, right. | From center of impact, longitudinal. | | From center of impact, lateral. | |
|---|---|---|---|---|---|---|
| | | | + | − | Right. | Left. |
| | *Yards.* | *Yards.* | *Yds.* | *Yds.* | *Yards.* | *Yds.* |
| 173 | 1,849 | 50 | 160 | | | 3.2 |
| 174 | 1,760 | 54 | 71 | | 0.8 | |
| 175 | 1,700 | 56 | 11 | | 2.8 | |
| 176 | 1,513 | 52 | | 176 | | 1.2 |
| 177 | 1,623 | 54 | | 66 | 0.8 | |
| | 8,445 | 266 | 242 | 242 | 4.4 | 4.4 |

| | *Yards.* |
|---|---|
| Mean range | 1,689 |
| Mean lateral deviation from plane of reference | 53.2 |
| Mean longitudinal deviation from center of impact | 96.8 |
| Mean lateral deviation from center of impact | 1.76 |

8,4+455=1,689 26+65=53.2 484+5=96.8 8.8+5=1.76

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1, Watervliet*

| Date. | | No. of fire. | Powder. | | Projectile. | | Elevation. | Time of flight. | Wind strength and di rection |
|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1890. | | | | *Pounds.* | | *Lbs. Oz.* | ° ′ | *Secs.* | |
| Oct. 30 | A. M ... | 178 | Du Pont's I. K. H. Lot 1. Density, 1.725. Granulation, 2,050. | 1 | Shell (banded), experimental. Lot 249. | 19 2<br>14 sand.<br>20 0 | 15 00 | 8 | From right, 18 miles an hour. |
| | | 179 | | 1 | | 18 13<br>1 3 sand.<br>20 0 | 15 00 | 7 | |
| | | 180 | | 1 | | 19 8<br>13 sand.<br>20 0 | 15 00 | 10 | |
| | | 181 | | 1 | | 19 0<br>1 0 sand.<br>20 0 | 15 00 | 11 | |
| | | 182 | | 1 | | 19 2<br>14 sand.<br>20 0 | 15 00 | 11 | |

TARGET.

| No. of round. | Range. | Deviation, right. |
|---|---|---|
| | *Yards.* | *Yards.* |
| 178 | 2,096 | 8 |
| 179 | 1,892 | 9 |
| 180 | 2,016 | 5 |
| 181 | 1,995 | 6 |
| 182 | 1,877 | 11 |

| | *Yards.* |
|---|---|
| Greatest range | 2,096 |
| Least range | 1,8 |
| Dispersion in range | 21 |
| Greatest deviation from plane of reference | 11 |
| Least deviation from plane of reference | |
| Lateral dispersion | 6 |

*Arsenal, at Sandy Hook, N. J., October 30, 1890*—Continued.

| | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|
| Fired down the beach | |
| | Pieces of unburnt cartridge bag, not holding fire, found on face of muzzle and in muzzle. |
| | Mortar fell forward off platform. After this round mortar was sponged out and chamber oiled. |
| | Rope restraining recoil broken. |
| | Mortar fell forward off platform; mortar sponged out. |

TARGET.

| No. of round. | Range. | Lateral deviation from plane of reference, right. | From center of impact, longitudinal. | | From center of impact, lateral. | |
|---|---|---|---|---|---|---|
| | | | + | − | Right. | Left. |
| | *Yards.* | *Yards.* | *Yds.* | *Yds.* | *Yards.* | *Yds.* |
| 178 | 2,096 | 8 | 120.8 | ...... | 0.2 | ...... |
| 179 | 1,892 | 9 | ...... | 83.2 | 1.2 | ...... |
| 180 | 2,016 | 5 | 40.8 | ...... | ...... | 2.8 |
| 181 | 1,995 | 6 | 19.8 | ...... | ...... | 1.8 |
| 182 | 1,877 | 11 | ...... | 98.2 | 3.2 | ...... |
| | 9,876 | 39 | 181.4 | 181.4 | 4.6 | 4.6 |

| | *Yards.* |
|---|---|
| Mean range | 1,975.2 |
| Mean lateral deviation from plane of reference | 7.8 |
| Mean longitudinal deviation from center of impact | 72.56 |
| Mean lateral deviation from center of impact | 1.84 |

9,876÷5=1,975.2 39÷5=7.8 362.8÷5=72.56 9.2÷5=1.84

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1, Watervlie*

| Date. | | No. of fire. | Powder. | | Projectile. | | Elevation. | Time of flight. | Recoil |
|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1890. | | | | *Ounces.* | | *Lbs. Oz.* | ° ′ | *Secs.* | *Inche* |
| Oct. 30 | A. M. | 183 | Du Pont's I. K. H. Lot 1. Density, 1.725. Granulation, 2,050. | 11 | Shell (banded), experimental. Lot 249. | 18 12 sand.<br>1 4<br>20 0 | 45 00 | 22½ | 4 |
| | | 184 | | 11 | | 19 4 sand.<br>12<br>20 0 | 45 00 | 22 | 4 |
| | | 185 | | 11 | | 18 13 sand.<br>1 3<br>20 0 | 45 00 | Lost. | 6 |
| | | 186 | | 11 | | 19 1 sand.<br>15<br>20 0 | 45 00 | 22 | 6 |
| | | 187 | | 11 | | 19 2 sand.<br>14<br>20 0 | 45 00 | 22½ | 6 |

TARGET.

| No. of round. | Range. | Deviation, right. |
|---|---|---|
| | *Yards.* | *Yards.* |
| 183 | 2,103 | 61 |
| 184 | 2,192 | 54 |
| 185 | 2,169 | 66 |
| 187 | 2,182 | 59 |

| | *Yard* |
|---|---|
| Greatest range | 2,19 |
| Least range | 2,10 |
| Dispersion in range | 8 |
| Greatest deviation from plane of reference | 6 |
| Least deviation from plane of reference | 5 |
| Lateral dispersion | 1 |

*Arsenal, at Sandy Hook, N. J., October 30, 1890*—Continued.

| Wind, strength and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|
| From right, 18 miles an hour. | Fired down the beach | Elevation after fire, 63° 45′. |
| | | Elevation after fire, 55°. |
| | | Elevation after fire, 70°. Location of shell could not be found. |
| | | Elevation after fire, 66° 30′. |
| | | Elevation after fire, 60° 30′. |

TARGET.

| No. of round. | Range. | Lateral deviation from plane of reference, right. | From center of impact, longitudinal. + | From center of impact, longitudinal. − | From center of impact, lateral. Right. | From center of impact, lateral. Left. |
|---|---|---|---|---|---|---|
| | *Yards.* | *Yards.* | *Yds.* | *Yds.* | *Yards.* | *Yds.* |
| 183 | 2,103 | 61 | ...... | 58.5 | 1 | ...... |
| 184 | 2,192 | 54 | 30.5 | ...... | ...... | 6 |
| 186 | 2,169 | 66 | 7.5 | ...... | 6 | ...... |
| 187 | 2,182 | 59 | 20.5 | ...... | ...... | 1 |
| | 8,646 | 240 | 58.5 | 58.5 | 7 | 7 |

| | *Yards.* |
|---|---|
| Mean range | 2,161.5 |
| Mean lateral deviation from plane of reference | 60 |
| Mean longitudinal deviation from center of impact | 29.25 |
| Mean lateral deviation from center of impact | 3.5 |

8,646÷4=2161.5 240÷4=60 117÷4=29.25 14÷4=3.5

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1, Watervliet*

| Date. | | No. of fire. | Powder. | | Projectile. | | Elevation. | Time of flight. | Wind strength and di rection |
|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1890. | | | | *Pounds.* | | *Lbs. Oz.* | ° ′ | *Secs.* | |
| Oct. 30 | P. M.... | 188 | Du Pont's I. K. H. Lot 1. Density, 1.725. Granulation, 2,050. | 1 | Shell (banded), experimental. Lot 249. | 18 14<br>1 2 sand.<br>20 0 | 45 00 | 26 | From right, 18 miles an hour. |
| | | 189 | | 1 | | 19 4<br>12 sand.<br>20 0 | 45 00 | 27 | |
| | | 190 | | 1 | | 19 1<br>15 sand.<br>20 0 | 45 00 | Lost. | |
| | | 191 | | 1 | | 19 5<br>11 sand.<br>20 0 | 45 00 | 28 | |
| | | 192 | | 1 | | 19 2<br>14 sand.<br>20 0 | 45 00 | 27 | |
| | | 193 | | 1 | | 19 2<br>14 sand.<br>20 0 | 45 00 | 27 | |
| | | 194 | | 1 | | 19 4<br>12 sand.<br>20 0 | 45 00 | Lost. | |
| | | 195 | | 1 | | 18 13 sand.<br>1 3<br>20 0 | 45 00 | 28 | |

TARGET.

| No. of round. | Range. | Deviation, right. |
|---|---|---|
| | *Yards.* | *Yards.* |
| 189 | 3,408 | 88 |
| 190 | 3,433 | 89 |
| 191 | 3,355 | 81 |
| 192 | 3,447 | 88 |
| 193 | 3,313 | 107 |

| | *Yards* |
|---|---|
| Greatest range | 3,44 |
| Least range | 3, |
| Dispersion in range | 1 |
| Greatest deviation from plane of reference | |
| Least deviation from plane of reference | |
| Lateral dispersion | |

*Arsenal, at Sandy Hook, N. J., October 30, 1890*—Continued.

| | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|
| Rope drawn taut before each fire. The mortar recoiled about 6 inches, stretching the rope, which, reacting, drew the mortar forward 15 inches in front of its firing position.<br>Fired down the beach.<br>Deviations measured from a line approximate to line of fire. | Sighting shot. Aimed at center of 3,000-yard target; location of shot could not be found. |
| | Sighting shot. Aimed at left edge of 3,000-yard target. |
| | Sighting shot. Aimed at left edge of 3,000-yard target. |
| | Direction of line of fire moved farther to the left. |
| | Location of shell could not be found. |
| | Location of shell could not be found. |
| Mortar sighted by Lieut. O. M. Lissak, O. D. Fall of projectiles and time of flight observed by Sergt. Johnston, O. D.<br>Firing conducted by Lieut. O. M. Lissak, O. D., assistant proof officer. | |

TARGET.

| No. of round. | Range. | Lateral deviation from plane of reference, right. | From center of impact, longitudinal. | | From center of impact, lateral. | |
|---|---|---|---|---|---|---|
| | | | + | — | Right. | Left. |
| | *Yards.* | *Yards.* | *Yds.* | *Yds.* | *Yards.* | *Yds.* |
| 189 | 3,408 | 88 | 16.8 | | | 2.6 |
| 190 | 3,483 | 89 | 41.8 | | | 1.6 |
| 191 | 3,355 | 81 | | 36.2 | | 9.6 |
| 192 | 3,447 | 88 | 55.8 | | | 2.6 |
| 193 | 3,313 | 107 | | 78.2 | 16.4 | |
| | 16,956 | 453 | 114.4 | 114.4 | 16.4 | 16.4 |

| | *Yards.* |
|---|---|
| Mean range | 3,391.2 |
| Mean lateral deviation from plane of reference | 90.6 |
| Mean longitudinal deviation from center of impact | 45.76 |
| Mean lateral deviation from center of impact | 6.56 |

16,956÷5 = 3,391.2   453÷5 = 90.6   228.8÷5 = 45.76   32.8÷6.56

***Record of firing with 3.6-inch B. L. field mortar (steel), No. 1,***

[Object of firing, to obtain

| Date. | | No. of fire. | Powder. | | Projectile. | | Elevation. | Instrumental velocity, 50 feet from muzzle. | Pressure per square inch of bore. |
|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1890. | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ′ | *Feet.* | *Pounds.* |
| Nov. 6 | A. M. | 196 | Du Pont's I. K. H. Lot 1. Density, 1.725. Granulation, 2,050. | 1 0 | Shell (banded), experimental. Lot 249. | 19 2<br>14 sand.<br>20 0 | 0 45 | 633 | No. 4, 16,060 |
| | | 197 | | 1 0 | | 19 4<br>12 sand.<br>20 0 | 0 45 | 626 | No. 4, 15,320 |
| | | 198 | | 1 0 | | 19 3<br>13 sand.<br>20 0 | 0 45 | 595 | No. 4, 15,165 |
| | | 199 | | 1 0 | | 19 4<br>12 sand.<br>20 0 | 0 45 | 630 | No. 4, 15,440 |
| | | 200 | | 0 11 | | 18 15<br>1 1 sand.<br>20 0 | 1 00 | Lost.... | No. 4, 9,225 |
| | | 201 | | 0 11 | | 19 1<br>15 sand.<br>20 0 | 1 00 | 521 | No. 4, 9,125 |
| | | 202 | | 0 11 | | 19 2<br>14 sand.<br>20 0 | 1 00 | 480 | No. 4, 9,275 |
| | | 203 | | 0 11 | | 19 3<br>13 sand.<br>20 0 | 1 00 | 502<br>25+$\frac{4}{12}$ | No. 4, less than 9,060. |
| | | 204 | | 0 8 | | 19 1<br>15 sand.<br>20 0 | 1 15 | *20 feet.*<br>Lost.... | No. 4, 6,065 |
| | | 205 | | 0 8 | | 19 1<br>15 sand.<br>20 0 | 1 15 | Lost.... | No. 4, 6,465 |
| | | 206 | | 0 8 | | 19 1<br>15 sand.<br>20 0 | 1 15 | 406 | No. 4, 6,065 |
| | | 207 | | 0 8 | | 19 2<br>14 sand.<br>20 0 | 1 15 | Lost....<br>10+$\frac{3}{12}$ | No. 4, 5,835 |
| | | 208 | | 0 5 | | 19 4<br>12 sand.<br>20 0 | 2 00 | .......... | No. 4, 2,750 |
| | | 209 | | 0 5 | | 19 4<br>12 sand.<br>20 0 | 2 00 | .......... | No. 4, 3,165 |
| | | 210 | | 0 3 | | 18 13<br>1 3 sand.<br>20 0 | 3 00 | .......... | No. 4, 2,750 |
| | | 211 | | 0 3 | | 19 1<br>15 sand.<br>20 0 | 3 00 | .......... | No. 4, 9,000 |

*Watervliet Arsenal, at Sandy Hook, N. J., November 6, 1890.*

**velocities and pressures.]**

| Recoil. | Wind, strength and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|
| *Feet.* | | Mortar mounted on new experimental carriage made at Watervliet Arsenal. | |
| 10 | From front and right, 8 miles an hour. | | |
| 10 | | Fired from wooden platform of 4-inch plank 14 feet long. Recoil restrained by 5-inch rope, fastened to round post 10 feet in front of platform and attached to bight of rope spliced through loops of carriage. | |
| 10 | | Fired into field butt, section 2. | |
| 10 | | Copper cylinders of 9,000 pounds initial compression and tables of 1887. | |
| 9 | | | |
| 9 | | | |
| 9 | | Cannon friction primers (experimental), with modified priming, March, 1890. | |
| 9 | | Copper cylinders of 9,000 pounds, initial compression and tables of 1887 used in rounds 200 to 208, inclusive. | |
| 8 | | | |
| 8 | | Fired into field butt, section 2. | |
| 8 | | Uncompressed copper cylinders and tables of 1890 used in rounds 204 to 208, inclusive. | |
| 8 | | | |
| 6 | | | |
| 6 | | | |
| 5 | | | |
| 5 | | Cannon friction primers (experimental), with modified priming, March 1890.<br>Fired into field butt, section 2.<br>Uncompressed copper cylinders and tables of 1890.<br>Velocities and pressure taken by Lieut. O. M. Lissak, O. D.<br>Firing conducted by Lieut. O. M. Lissak, O. D. assistant proof officer. | |

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1, Watervliet*

[Object of firing, to

| Date. | | No. of fire. | Powder. Kind. | Powder. Weight. Lbs. | Powder. Weight. Oz. | Projectile. Kind. | Projectile. Weight. Lbs. | Projectile. Weight. Oz. | | Elevation. ° | Elevation. ′ | Recoil. Ft. | Recoil. In. | Wind, strength and direction. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1890. Nov. 24 | P. M. | 212 | Du Pont's I. K. H. Lot 1. Density, 1.725. Granulation, 2,050. | 0 | 11 | Shell (banded), experimental. Lot 249. | 19 | 4 | natural weight. | 45 | 00 | 3 | 0 | From right, 10 miles an hour. |
| | | 213 | | 1 | 0 | | 19 | 4 | natural weight. | 45 | 00 | 6 | 0 | |
| Nov. 25 | A. M. | 214 | | 1 | 0 | | 19<br><br>20 | 2<br>14<br>0 | <br>sand. | 45 | 00 | 8 | 0 | From right, 9 miles an hour. |
| | | 215 | | 1 | 0 | | 19<br><br>20 | 12<br>4<br>0 | <br>sand. | 45 | 00 | 4 | 0 | |
| | | 216 | | 1 | 0 | | 19<br><br>20 | 2<br>14<br>0 | <br>sand. | 45 | 00 | 4 | 0 | |
| | | 217 | | 1 | 0 | | 19<br><br>20 | 1<br>15<br>0 | <br>sand. | 15 | 00 | 6 | 0 | |
| | | 218 | | 1 | 0 | | 19<br><br>20 | 4<br>12<br>0 | <br>sand. | 15 | 00 | 6 | 0 | |
| | | 219 | | 1 | 0 | | 19<br>1<br>20 | 0<br>0<br>0 | <br>sand. | 15 | 00 | 7 | 0 | |
| | | 220 | | 1 | 0 | | 19<br><br>20 | 5<br>11<br>0 | <br>sand. | 15 | 00 | 9 | 0 | |
| | | 221 | | 1 | 0 | | 19<br><br>20 | 4<br>12<br>0 | <br>sand. | 60 | 00 | 0 | 8 | |
| | | 222 | | 1 | 0 | | 19<br><br>20 | 1<br>15<br>0 | <br>sand. | 60 | 00 | 1 | 0 | |

[Object of firing, to test feasibility of using 1 pound

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dec. 19 | A. M. | 223 | DuPont's I. K. H. Lot 16. Density, 1.725. Granulation, 2,524. | 1 | 0 | Shell (banded), experimental. Lot 249. | 19<br>1<br>20 | 0<br>0<br>0 | <br>sand. | 0 | 45 | 10 | 0 | From right and rear, 25 miles an hour. |

*Arsenal, at Sandy Hook, N. J., from November 24 to December 19, 1890.*

**test mortar carriage.]**

| | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|
| Mortar mounted on new experimental cast-steel carriage made at Watervliet Arsenal. Cannon friction primers (experimental), with modified priming, March, 1890. | |
| Fired from field gun platform.<br>Recoil unrestrained.<br>Fired to sea.<br>Powder put up in 3.2-inch cartridge bags, which rendered closing of breechblock difficult. | Mortar nearly horizontal after fire. |
| | Elevation after fire, 42°. |
| | Free recoil. Pieces of unburnt cartridge bag not holding fire found in bore elevation after fire, 43° 45′. |
| | Recoil restrained by 2½-inch rope; rope allowed recoil of 4 feet. Elevation after fire, 42° 30′. |
| | Elevation after fire, 44° 10′. |
| | Rope restraining recoil broke. Elevation after fire, 16° 10′. |
| | Recoil restrained by 2½-inch rope doubled, allowing recoil of 6 feet. No change in elevation after fire. |
| | Elevation after fire, 16° 30′. |
| | Rope removed from post and passed over iron bar driven into the sand. Rope slipped over bar at discharge. Elevation after fire, 16° 10′. |
| | Rope restraining recoil removed. Elevation after fire, 59° 15′. |
| | No change in elevation after fire. |
| Firing conducted by Lieut. O. M. Lissak, O. D. Present, Capt. R. Birnie, O. D., assistant proof officer.<br>Mortar star gauged after round 222 November 27, 1890, by Lieut. O. M. Lissak, O. D. | |

**charge loose in chamber without cartridge bag.]**

| | |
|---|---|
| Mortar mounted on new experimental steel carriage made at Watervliet Arsenal. Cannon friction primers (experimental), with modified priming, March, 1890. | |
| Stops of vent shield have been replaced by longer ones.<br>Fired into field butt, section 1. | As the construction of carriage does not permit of any depression being given piece before insertion of cartridge, the rear end of carriage was raised so as to bring the piece nearly vertical.<br>Mortar turned over on left side. |
| Firing conducted by Lieut. O. M. Lissak, O. D., assistant proof officer. | |

*Record of firing with 3.6-inch B. L. field mortar (steel), No.*

[Object of firing, to obtain

| Date. | | No. of fire. | Powder. | | Projectile. | | Elevation. | Instrumental velocity, 50 feet from muzzle. | Pressure per square inch of bore. |
|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | | |
| | | | | *Lbs. Oz.* | | *Lbs. Oz.* | ° ′ | *Feet.* | *Pounds* |
| 1891.<br>Jan. 8 | P. M. | 224 | Du Pont's I. K. H. Lot 16. Density, 1.725. Granulation, 2.524. | 1 0 | Shell (banded), experimental. Lot 249. | 19 1<br>15 sand.<br>20 0 | 0 45 | 650 | No. 4, 16,570 |
| | | 225 | | 1 0 | | 19 2<br>14 sand.<br>20 0 | 0 45 | 636 | No. 4, 15,35 |
| | | 226 | | 1 0 | | 19 3<br>13 sand.<br>20 0 | 0 45 | 633 | No. 4, 15,200 |
| | | 227 | | 0 11 | | 19 1<br>15 sand.<br>20 0 | 0 45 | 507 | No. 4, 9,250 |
| | | 228 | | 0 11 | | 19 5<br>11 sand.<br>20 0 | 0 55 | 509 | No. 4, 9,225 |
| | | 229 | | 0 11 | | 19 3<br>13 sand.<br>20 0 | 1 00 | 501<br>25 + $\frac{4}{9}$ | No. 4, 9,600 |
| | | 230 | | 0 8 | | 19 3<br>13 sand.<br>20 0 | 1 30 | *20 feet*<br>415 | No. 4, 6,130 |
| | | 231 | | 0 8 | | 19 1<br>15 sand.<br>20 0 | 2 00 | Lost.... | No. 4, 5,940 |
| | | 232 | | 0 8 | | 19 3<br>13 sand.<br>20 0 | 2 00 | 416 | No. 4, 6,300 |
| | | 233 | | 0 5 | | 19 2<br>14 sand.<br>20 0 | 3 00 | Lost....<br>20 + $\frac{2}{9}$ | 3,500 |

*Watervleit Arsenal, at Sandy Hook, N. J., January 8, 1891.*

**velocities and pressures.]**

| Wind, strength and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|
| | Mortar mounted on new experimental steel carriage made at Watervliet Arsenal. Cannon friction primers (experimental), with modified priming, March, 1890. | |
| From rear, 14 miles an hour. | Fired into field butt, section 1. Uncompressed copper cylinders and tables of 1890. | Recoil restrained by 2½-inch rope strap through rings of carriage and over post in front and to left of piece. Rope allows recoil of 3 feet. Rope broke. Mortar turned over backwards three times in recoiling 15 feet. Upper handle of breechblock turned in towards the piece. Shaving gouged from left side of elevating arc. |
| | | Recoil rope passed through rings of carriage and fastened to two holdfasts in front and on each side. Rope allows recoil of 6 feet. Rope broke. Recoil 13 feet. |
| | | ¾-inch iron bar passed through loops of carriage. Rope strap made fast to bar. Recoil rope passed through straps and fastened as in last round. Rope allows recoil of 6 feet. |
| | | Wires of rear velocity target not cut. |
| | | Wires of velocity targets not cut. |
| | Pressures and velocities taken by Lieut. W. W. Gibson, O. D. Firing conducted by Lieut. W. W. Gibson, O. D., assistant proof officer. | |

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1.*

[Object of firing, to test

| Date. | | No. of series. | No. of fire. | Powder. | | Projectile. | | Elevation. | Recoil. | Wind strength and direction. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1891. | | | | | Oz. | | Lbs. Oz. | ° ′ | Ft. In. | |
| Jan. 9 | A. M..... | 1 | 234 | Du Pont's I. K. H. Lot 16. Density, 1.725. Granulation, 2,524. | 3 | Shell (banded). Experimental. Lot 240. | 19 2<br>14 sand.<br>20 0 | 15 00 | 3 0 | From left and front, 9 miles an hour. |
| | | 2 | 235 | | 3 | | 19 2<br>14 sand.<br>20 0 | 15 00 | 3 0 | |
| | | 3 | 236 | | 3 | | 19 4<br>12 sand.<br>20 0 | 15 00 | 2 10 | |
| | | 4 | 237 | | 3 | | 19 4<br>12 sand.<br>20 0 | 15 00 | 2 7 | |
| | | 5 | 238 | | 3 | | 19 2<br>14 sand.<br>20 0 | 15 00 | 2 7 | |
| | | 6 | 239 | | 3 | | 19 5<br>11 sand.<br>20 0 | 15 00 | 2 8 | |
| | | 7 | 240 | | 3 | | 19 4<br>12 sand.<br>20 0 | 15 00 | 2 10 | |
| | | 8 | 241 | | 3 | | 19 4<br>12 sand.<br>20 0 | 15 00 | 3 0 | |
| | | 9 | 242 | | 3 | | 19 2<br>14 sand.<br>20 0 | 15 00 | 3 0 | |
| | | 10 | 243 | | 3 | | 19 3<br>13 sand.<br>20 0 | 15 00 | 2 10 | |
| | | 11 | 244 | | 3 | | 19 3<br>13 sand.<br>20 0 | 15 00 | 2 10 | |

## TARGET.

| No. of round. | Range. | Deviation, right. |
|---|---|---|
| | Yards. | Yards. |
| 235 | 307 | 4 |
| 236 | 325 | 3 |
| 237 | 312 | 3 |
| 238 | 325 | 3 |
| 239 | 305 | 3 |
| 240 | 319 | 3 |
| 241 | 323 | 3 |
| 242 | 305 | 3 |
| 243 | 323 | 3 |
| 244 | 341 | 3 |

| | Yards. |
|---|---|
| Greatest range | 341 |
| Least range | 305 |
| Dispersion in range | 36 |
| Greatest deviation from plane of reference | 4 |
| Least deviation from plane of reference | 3 |
| Lateral dispersion | 1 |

*Watervliet Arsenal, at Sandy Hook, N. J., January 9, 1891.*

accuracy of mortar.]

| Time of flight. | | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|
| First stop-watch.* | Second stop-watch.† | | |
| | | Mortar mounted on new experimental steel carriage made at Watervliet Arsenal. Cannon friction primers (experimental), with modified priming, March, 1890. | |
| *Secs.* 4½ | *Secs.* 4½ | Direction given by planed iron strip nailed to platform.<br>Fired down the beach. | Sighting shot. Range, 346 yards. Deviation to right of plane of reference, 2 yards. |
| 4⅕ | 4 | | |
| 4⅕ | 4 | | |
| 4⅕ | 4 | | |
| 4⅕ | 4 | | First primer failed. |
| 4⅕ | 4 | | |
| 4⅕ | 4 | | |
| 4⅕ | 4 | | |
| 4⅕ | 4½ | | |
| 4⅖ | 4½ | | |
| 4⅖ | 4⅖ | | |
| | | Mortar sighted by Lieut. O. M. Lissak, O. D. Fall of projectile observed by Sergt. Johnston, ordnance detachment. | |

* Held by Lieut. O. M. Lissak, O. D. † Held by Sergt. Johnston, ordnance detachment.

TARGET.

| No. of round. | Range. | Lateral deviation from plane of reference, right. | From center of impact, longitudinal. | | From center of impact, lateral. | |
|---|---|---|---|---|---|---|
| | | | + | − | Right. | Left. |
| | *Yards.* | *Yards.* | *Yds.* | *Yds.* | *Yards.* | *Yds.* |
| 235 | 307 | 4 | | 11.5 | .90 | .10 |
| 236 | 325 | 3 | 6.5 | | | .10 |
| 237 | 312 | 3 | | 6.5 | | .10 |
| 238 | 325 | 3 | 6.5 | | | .10 |
| 239 | 306 | 3 | | 13.5 | | .10 |
| 240 | 319 | 3 | .5 | | | .10 |
| 241 | 323 | 3 | 4.5 | | | .10 |
| 242 | 305 | 3 | | 13.5 | | .10 |
| 243 | 323 | 3 | 4.5 | | | .10 |
| 244 | 341 | 3 | 22.5 | | | .10 |
| | 3,185 | 31 | 45 | 45 | .90 | .90 |

| | *Yards.* |
|---|---|
| Mean range | 318.5 |
| Mean lateral deviation from plane of reference | 3.1 |
| Mean longitudinal deviation from center of impact | 9 |
| Mean lateral deviation from center of impact | .18 |

3,185 ÷ 10 = 318.5 31 ÷ 10 = 3.1 90 ÷ 10 = 9 1.80 ÷ 10 = 0.18

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1, Watervli*

[Object of firing, to test

| Date. | | No. of series. | No. of fire. | Powder. | | Projectile. | | Elevation. | Recoil. | Wind, strength and direction. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1891. | | | | | *Ounces.* | | *Lbs. Oz.* | ° ′ | *Ft. In.* | |
| Jan. 9 | A. M. | 12 | 245 | Du Pont's I. K. H. Lot 16. Density, 1.725. Granulation, 2,524. | 5 | Shell (banded), experimental. Lot 249. | 19 3<br>13 sand.<br>20 0 | 15 00 | 5 6 | From left and front, 9 miles an hour |
| | | 13 | 246 | | 5 | | 19 3<br>13 sand.<br>20 0 | 15 00 | 5 6 | |
| | | 14 | 247 | | 5 | | 19 3<br>13 sand.<br>20 0 | 15 00 | 6 2 | |
| | | 15 | 248 | | 5 | | 18 15<br>1 1 sand.<br>20 0 | 15 00 | 6 3 | |
| | | 16 | 249 | | 5 | | 19 3<br>13 sand.<br>20 0 | 15 00 | 6 0 | |
| | | 17 | 250 | | 5 | | 19 3<br>13 sand.<br>20 0 | 15 00 | 6 0 | |
| | | 18 | 251 | | 5 | | 19 1<br>15 sand.<br>20 0 | 15 00 | 5 6 | |
| | | 19 | 252 | | 5 | | 19 3<br>13 sand.<br>20 0 | 15 00 | 6 6 | |
| | | 20 | 253 | | 5 | | 19 3<br>13 sand.<br>20 0 | 15 00 | 6 3 | |
| | | 21 | 254 | | 5 | | 19 4<br>12 sand.<br>20 0 | 15 00 | 6 2 | |

TARGET.

| No. of round. | Range. | Deviation, right. |
|---|---|---|
| | *Yards.* | *Yards.* |
| 245 | 558 | 4 |
| 246 | 563 | 2 |
| 247 | 579 | 3 |
| 248 | 583 | 3 |
| 249 | 549 | 3 |
| 250 | 525 | 4 |
| 251 | 482 | 4 |
| 252 | 597 | 3 |
| 253 | 562 | 4 |
| 254 | 585 | 4 |

| | *Yards* |
|---|---|
| Greatest range | 58 |
| Least range | 48 |
| Dispersion in range | 10 |
| Greatest deviation from plane of reference | 4 |
| Least deviation from plane of reference | 2 |
| Lateral dispersion | 2 |

*Arsenal, at Sandy Hook, N. J., January 9, 1891*—Continued.

accuracy of mortar.]

| Time of flight. | | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|
| First stop-watch.* | Second stop-watch.† | | |
| *Secs.* | *Secs.* | Mortar mounted on new experimental steel carriage made at Watervliet Arsenal. | |
| 6 | 5¾ | Direction given by planed iron strip nailed to platform.<br>Fired down the beach.<br>Seven or eight shells broke in two parts at rotating band on striking ground. | |
| 6 | 5½ | | |
| 6 | 5¾ | | |
| 6 | 6 | | |
| Lost. | Lost. | | Shell broke up in mortar. Base of shell struck at about 300 yards; time of flight of base, 5½ seconds. |
| 5½ | 5½ | | |
| 5¾ | 5½ | | |
| 6½ | 6 | | |
| 6 | 5¾ | | |
| 6 | 5¾ | | |
| | | Mortar sighted by Lieut. O. M. Lissak, O. D. Fall of projectile observed by Sergt. Johnston, ordnance detachment. | |

* Held by Lieut. O. M. Lissak, O. D. † Held by Sergt. Johnston, ordnance detachment.

## TARGET.

| No. of round. | Range. | Lateral deviation from plane of reference, right. | From center of impact, longitudinal. | | From center of impact, lateral. | |
|---|---|---|---|---|---|---|
| | | | + | − | Right. | Left. |
| | *Yards.* | *Yards.* | *Yds.* | *Yds.* | *Yards.* | *Yds.* |
| 245 | 558 | 4 | ...... | .3 | .6 | ...... |
| 246 | 563 | 2 | 4.7 | ...... | ........ | 1.4 |
| 247 | 579 | 3 | 20.7 | ...... | ........ | .4 |
| 248 | 583 | 3 | 24.7 | ...... | ........ | .4 |
| 249 | 549 | 3 | ...... | 9.3 | ........ | .4 |
| 250 | 525 | 4 | ...... | 33.3 | .6 | ...... |
| 251 | 482 | 4 | ...... | 76.3 | .6 | ...... |
| 252 | 597 | 3 | 38.7 | ...... | ........ | .4 |
| 253 | 562 | 4 | 3.7 | ...... | .6 | ...... |
| 254 | 585 | 4 | 26.7 | ...... | .6 | ...... |
| | 5,583 | 34 | 119.2 | 119.2 | 3.0 | 3.0 |

| | *Yards.* |
|---|---|
| Mean range | 558.3 |
| Mean lateral deviation from plane of reference | 3.4 |
| Mean longitudinal deviation from center of impact | 23.84 |
| Mean lateral deviation from center of impact | 60 |

5,583÷10=558.3 34÷10=3.4 238.4÷10=23.84 6.0÷10=0.60

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1, Watervliet*

[Object of firing, to test

| Date. | | No. of series. | No. of fire. | Powder. | | Projectile. | | Elevation. | Recoil. | Wind, strength and direction. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1891. | | | | | *Ounces.* | | *Lbs. Oz.* | ° ′ | *Feet.* | |
| Jan. 9 | P. M. | 22 | 255 | Du Pont's I. K. H. Lot 16. Density, 1.725. Granulation, 2,524. | 3 | Shell, experimental. Lot 249. | 19 4<br>12 sand.<br>20 0 | 15 00 | 4 | From left and front, 8 miles an hour. |
| | | 23 | 256 | | 3 | Mortar shell (lot 273), specially provided for accuracy test. | 18 13<br>1 3 sand.<br>20 0 | 15 00 | 3½ | |
| | | 24 | 257 | | 3 | | 18 11<br>1 5 sand.<br>20 0 | 15 00 | 4 | |
| | | 25 | 258 | | 3 | | 18 14<br>1 2 sand.<br>20 0 | 15 00 | 4 | |
| | | 26 | 259 | | 3 | | 18 14<br>1 2 sand.<br>20 0 | 15 00 | 4 | |
| | | 27 | 260 | | 3 | | 18 15<br>1 1 sand.<br>20 0 | 15 00 | 4 | |
| | | 28 | 261 | | 3 | | 18 13<br>1 3 sand.<br>20 0 | 15 00 | 3½ | |
| | | 29 | 262 | | 3 | | 18 12<br>1 4 sand.<br>20 0 | 15 00 | 4 | |
| | | 30 | 263 | | 3 | | 18 13<br>1 3 sand.<br>20 0 | 15 00 | 4 | |
| | | 31 | 264 | | 3 | | 18 14<br>1 2 sand.<br>20 0 | 15 00 | 4 | |
| | | 32 | 265 | | 3 | | 18 13<br>1 3 sand.<br>20 0 | 15 00 | 4 | |

TARGET.

| No. of round. | Range. | Deviation, right. |
|---|---|---|
| | *Yards.* | *Yards.* |
| 256 | 302 | 2 |
| 257 | 327 | 3 |
| 258 | 309 | 3 |
| 259 | 336 | 3 |
| 260 | 313 | 4 |
| 261 | 307 | 3 |
| 262 | 312 | 3 |
| 263 | 336 | 4 |
| 264 | 341 | 3 |
| 265 | 330 | 4 |

| | *Yards.* |
|---|---|
| Greatest range | 341 |
| Least range | 302 |
| Dispersion in range | 39 |
| Greatest deviation from plane of reference | 4 |
| Least deviation from plane of reference | 2 |
| Lateral dispersion | 2 |

| Time of flight. First stop-watch.* | Time of flight. Second stop-watch.† | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|
| | | Mortar mounted on new experimental steel carriage made at Watervliet Arsenal. Cannon friction primers (experimental), with modified priming, March, 1890. | |
| *Secs.* | *Secs.* | | |
| 4⅕ | 4 | | Sighting shot. Range, 338 yards. Deviation from plane of reference, 2 yards right. |
| 4½ | 3½ | | |
| 4½ | 3½ | | |
| 4⅕ | 4 | | |
| 4⅗ | 4 | | First primer broken; failed to ignite charge. |
| 4½ | 4 | Direction given by planed iron strip nailed to platform.<br>Fired down the beach. | |
| ........ | 3½ | | First stop-watch broken. |
| ........ | 4½ | | |
| ........ | 4½ | | |
| ........ | 4½ | | |
| ........ | 4 | | |
| | | Mortar sighted by Lieut. O. M. Lissak, O. D. Fall of projectile observed by Sergt. Warwick, ordnance detachment. | |

*Held by Lieut. O. M. Lissak, O. D. †Held by Sergt. Warwick, ordnance detachment.

TARGET.

| No. of round. | Range. | Lateral deviation from plane of reference, right. | From center of impact, longitudinal. | | From center of impact, lateral. | |
|---|---|---|---|---|---|---|
| | | | + | − | Right. | Left. |
| | *Yards.* | *Yards.* | *Yds.* | *Yds.* | *Yards.* | *Yds.* |
| 56........ | 302 | 2 | ...... | 19.3 | ........ | 1.2 |
| 57........ | 327 | 3 | 5.7 | ...... | ........ | 0.2 |
| 58........ | 309 | 3 | ...... | 12.3 | ........ | 0.2 |
| 59........ | 336 | 3 | 14.7 | ...... | ........ | 0.2 |
| 60........ | 313 | 4 | ...... | 8.3 | 0.8 | ...... |
| 61........ | 307 | 3 | ...... | 14.3 | ........ | 0.2 |
| 62........ | 312 | 3 | ...... | 9.3 | ........ | 0.2 |
| 63........ | 336 | 4 | 14.7 | ...... | 0.8 | ...... |
| 64........ | 341 | 3 | 19.7 | ...... | ........ | 0.2 |
| 65........ | 330 | 4 | 8.7 | ...... | 0.8 | ...... |
| | 3,213 | 32 | 63.5 | 63.5 | 2.4 | 2.4 |

| | *Yards.* |
|---|---|
| Mean range ........................ | 321.3 |
| Mean lateral deviation from plane of reference ........................ | 3.2 |
| Mean longitudinal deviation from center of impact ........................ | 12.7 |
| Mean lateral deviation from center of impact ........................ | 48 |

3,213+10=321.3 32+10=3.2 127+10=12.7 4.8+10=0.48

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1, Watervliet*

(Object of firing, to test

| Date. | | No. of series. | No. of fire. | Powder. | | Projectile. | | Elevation. | Recoil. | Wind, strength and direction |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1891. | | | | | *Ounces.* | | *Lbs. Oz.* | ° ′ | *Ft. In.* | |
| Jan. 9 | P. M. | 33 | 266 | Du Pont's I. K. H. Lot 16. Density, 1.725. Granulation, 2,524. | 5 | Mortar shell (lot 273), specially provided for accuracy test. | 18 14<br>1 2 sand.<br>20 0 | 15 00 | 6 0 | From left and front, 8 miles an hour. |
| | | 34 | 267 | | 5 | | 18 11<br>1 5 sand.<br>20 0 | 15 00 | 6 0 | |
| | | 35 | 268 | | 5 | | 18 10<br>1 6 sand.<br>20 0 | 15 00 | 5 9 | |
| | | 36 | 269 | | 5 | | 18 15<br>1 1 sand.<br>20 0 | 15 00 | 6 0 | |
| | | 37 | 270 | | 5 | | 19 0<br>1 0 sand.<br>20 0 | 15 00 | 6 3 | |
| | | 38 | 271 | | 5 | | 18 12<br>1 4 sand.<br>20 0 | 15 00 | 6 1 | |
| | | 39 | 272 | | 5 | | 18 11<br>1 5 sand.<br>20 0 | 15 00 | 5 6 | |
| | | 40 | 273 | | 5 | | 18 13<br>1 3 sand.<br>20 0 | 15 00 | 6 0 | |
| | | 41 | 274 | | 5 | | 18 15<br>1 1 sand.<br>20 0 | 15 00 | 6 6 | |
| | | 42 | 275 | | 5 | | 19 0<br>1 0 sand.<br>20 0 | 15 00 | 6 3 | |

TARGET.

| No. of round. | Range. | Deviation, right. | | |
|---|---|---|---|---|
| | *Yards.* | *Yards.* | | *Yards.* |
| 266 | 561 | 4 | Greatest range | 564 |
| 267 | 508 | 5 | Least range | 502 |
| 268 | 515 | 5 | | |
| 269 | 564 | 5 | Dispersion in range | 62 |
| 270 | 530 | 4 | | |
| 271 | 631 | 5 | Greatest deviation from plane of reference | 5 |
| 272 | 502 | 5 | Least deviation from plane of reference | 4 |
| 273 | 521 | 4 | | |
| 274 | 558 | 5 | Lateral dispersion | 1 |
| 275 | 549 | 5 | | |

*Arsenal, at Sandy Hook, N. J., January 9, 1891*—Continued.

**accuracy of mortar.]**

| Time of flight. | | Special rema as effect or mechanism sound of p tering of fr logical data |
|---|---|---|
| | Mortar mounted on new experimental steel carriage made at Watervliet Arsenal. Cannon friction primers (experimental), with modified priming, March, 1890. | |
| *Secs.* 5½ | | |
| 5⅕ | | |
| 5½ | | |
| 5⅗ | | |
| 5½ | | Two primers |
| 5⅕ | Direction given by planed iron strip nailed to platform.<br>Fired down the beach. | |
| 5½ | | |
| 5⅖ | | |
| 5⅖ | | |
| 5⅕ | | |
| | Stop watch held by Sergt. Warwick, ordnance detachment. Mortar sighted by Lieut. O. M. Lissak, O. D. Fall of projectile observed by Sergt. Warwick, ordnance detachment.<br>Firing conducted by Lieut. O. M. Lissak, O. D., assistant proof officer. | |

TARGET.

| No. of round. | Range. | Lateral deviation from plane of reference. | From center of impact, longitudinal. | | From center of impact, lateral. | | |
|---|---|---|---|---|---|---|---|
| | | | + | − | Right. | Left. | |
| | *Yards.* | *Yards.* | *Yds.* | *Yds.* | *Yards.* | *Yds.* | |
| 266 | 561 | 4 | 27.1 | ...... | ........ | 0.7 | Mean range........... |
| 267 | 508 | 5 | ...... | 25.9 | 0.3 | ...... | Mean lateral deviatio reference ........... |
| 268 | 515 | 5 | ...... | 18.9 | 0.3 | ...... | |
| 269 | 564 | 5 | 30.1 | ...... | 0.3 | ...... | Mean longitudinal de ter of impact ....... |
| 270 | 530 | 4 | ...... | 3.9 | ........ | 0.7 | |
| 271 | 531 | 5 | ...... | 2.9 | 0.3 | ...... | Mean lateral deviatio impact............. |
| 272 | 502 | 5 | ...... | 31.9 | 0.3 | ...... | |
| 273 | 521 | 4 | ...... | 12.9 | ........ | 0.7 | |
| 274 | 558 | 5 | 24.1 | ...... | 0.3 | ...... | |
| 275 | 549 | 5 | 15.1 | ...... | 0.3 | ...... | |
| | 5,339 | 47 | 96.4 | 96.4 | 2.1 | 2.1 | |

5,339÷10=533.9 47÷10=4.7 1,928÷10=19.28 4.2÷1

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1,*

[Object of firing, to test

| Date. | | No. of series. | No. of fire. | Powder. | | Projectile. | | Elevation. | | Recoil. | Wind, strength and direction. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Kind. | Weight. | Kind. | Weight. | | | | |
| | | | | | *Ounces.* | | *Lbs. Oz.* | ° | ′ | *Feet.* | |
| 1891.<br>Jan. 10 | A. M. | 43 | 276 | Du Pont's I. K. H. Lot 16. Density, 1.725. Granulation, 2,524. | 8 | Shell (banded) experimental. Lot 249. | 19 3<br>13 sand.<br>20 0 | 15 | 00 | 11 | From left, 10 miles an hour. |
| | | 44 | 277 | | 8 | Mortar shell (lot 273), specially provided for accuracy test. | 18 12<br>1 4 sand.<br>20 0 | 15 | 00 | 11 | |
| | | 45 | 278 | | 8 | | 19 1<br>0 15 sand.<br>20 0 | 15 | 00 | 11 | |
| | | 46 | 279 | | 8 | | 18 12<br>1 4 sand.<br>20 0 | 15 | 00 | 11 | |
| | | 47 | 280 | | 8 | | 18 11<br>1 5 sand.<br>20 0 | 15 | 00 | 9 | |
| | | 48 | 281 | | 8 | | 18 12<br>1 4 sand.<br>20 0 | 15 | 00 | 5 | |
| | | 49 | 282 | | 8 | | 18 15<br>1 1 sand.<br>20 0 | 15 | 00 | 3½ | |
| | | 50 | 283 | | 8 | | 18 15<br>1 1 sand.<br>20 0 | 15 | 00 | 2 | |
| | | 51 | 284 | | 8 | | 18 13<br>1 3 sand.<br>20 0 | 15 | 00 | 2 | |
| | | 52 | 285 | | 8 | | 18 14<br>1 2 sand.<br>20 0 | 15 | 00 | 2 | |
| | | 53 | 286 | | 8 | | 18 13<br>1 3 sand.<br>20 0 | 15 | 00 | 2 | |

TARGET.

| No. of round. | Range. | Deviation right. |
|---|---|---|
| | *Yards.* | *Yards.* |
| 277 | 938 | 13 |
| 278 | 879 | 13 |
| 279 | 900 | 12 |
| 280 | 880 | 14 |
| 281 | 861 | 13 |
| 282 | 880 | 13 |
| 283 | 928 | 14 |
| 284 | 881 | 14 |
| 285 | 875 | 15 |
| 286 | 853 | 17 |

| | *Yards* |
|---|---|
| Greatest range | [illegible] |
| Least range | [illegible] |
| Dispersion in range | [illegible] |
| Greatest deviation from plane of fire | [illegible] |
| Least deviation from plane of fire | [illegible] |
| Lateral dispersion | [illegible] |

*Watervliet Arsenal, at Sandy Hook, N. J., January 10, 1891.*

accuracy of mortar.]

| Time of flight. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|
| | Mortar mounted on new experimental steel carriage made at Watervliet Arsenal. Cannon friction primers (experimental), with modified priming, March, 1890. | |
| *Secs.*<br>7½ | | Sighting shot. Range, 907 yards. Deviation from plane of fire, 12 yards, right. |
| 7½ | | |
| 7¼ | | |
| 7¼ | | |
| 7¼ | | Rope allowed recoil of 9 feet. |
| 7¼ | Direction given by planed strip of iron nailed to platform.<br>Fired down the beach.<br>Recoil restrained by 2¼-inch rope doubled, and arranged as in round 220. | First primer failed. Rope allowed recoil of 5 feet. |
| 7¼ | | First primer failed. Rope allowed recoil of 3½ feet. |
| 7¼ | | Rope allowed recoil of 2 feet. |
| 7 | | |
| 7 | | |
| 7 | | |
| | Stop watch held by Sergt. Warwick, ordnance detachment. Fall of projectile observed by Sergt. Warwick, ordnance detachment. Mortar sighted by Lieut. O. M. Lissak, O. D.<br>Firing conducted by Lieut. O. M. Lissak, O. D., assistant proof officer. | |

TARGET.

| No. of round. | Range. | Lateral deviation from plane of fire, right. | From center of impact, longitudinal. | | From center of impact, lateral. | |
|---|---|---|---|---|---|---|
| | | | + | − | Right. | Left. |
| | *Yards.* | *Yards.* | *Yds.* | *Yds.* | *Yds.* | *Yds.* |
| 277 | 938 | 13 | 50.5 | | | 0.8 |
| 278 | 879 | 13 | | 8.5 | | 0.8 |
| 279 | 900 | 12 | 12.5 | | | 1.8 |
| 280 | 880 | 14 | | 7.5 | 0.2 | |
| 281 | 861 | 13 | | 26.5 | | 0.8 |
| 282 | 880 | 13 | | 7.5 | | 0.8 |
| 283 | 928 | 14 | 40.5 | | 0.2 | |
| 284 | 881 | 14 | | 6.5 | 0.2 | |
| 285 | 875 | 15 | | 12.5 | 1.2 | |
| 286 | 853 | 17 | | 34.5 | 3.2 | |
| | 8,875 | 138 | 103.5 | 103.5 | 5.0 | 5.0 |

| | *Yards.* |
|---|---|
| Mean range | 887.5 |
| Mean lateral deviation from plane of fire | 13.8 |
| Mean longitudinal deviation from center of impact | 20.7 |
| Mean lateral deviation from center of impact | 1 |

8,875 ÷ 10 = 887.5    138 ÷ 10 = 13.8    207 ÷ 10 = 20.7    10 ÷ 10 = 1

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1.*

[Object of firing, to test

| Date. | | No. of series. | No. of fire. | Powder. | | Projectile. | | | Elevation. | | Recoil. | Wind strength and direction. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Kind. | Weight. | Kind. | Weight. | | | | | |
| 1891. | | | | | *Ounces.* | | *Lbs.* | *Oz.* | ° | ′ | *Feet.* | |
| | | 54 | 287 | Du Pont's I. K. H. Lot 16. Density, 1.725. Granulation, 2.524. | 11 | Shell (banded), experimental. Lot 249. | 19<br><br>20 | 3<br>13 sand.<br>0 | 15 | 00 | 5 | |
| | | 55 | 288 | | 11 | Mortar shell (lot 273), specially provided for accuracy test. | 18<br>1<br><br>20 | 10<br>2 sand.<br>4 lead.<br>0 | 15 | 00 | 5 | |
| | | 56 | 289 | | 11 | | 18<br>1<br>20 | 14<br>2 sand.<br>0 | 15 | 00 | 5 | From right and rear, 10 miles an hour. |
| | | 57 | 290 | | 11 | | 18<br>1<br><br>20 | 8<br>4 sand.<br>4 lead.<br>0 | 15 | 00 | 5 | |
| | | 58 | 291 | | 11 | | 18<br>1<br>20 | 10<br>6 sand.<br>0 | 15 | 00 | 5 | |
| Jan. 13 | P. M. | 59 | 292 | | 11 | | 18<br>1<br>20 | 15<br>1 sand.<br>0 | 15 | 00 | 5 | |
| | | 60 | 293 | | 11 | | 18<br>1<br><br>20 | 10<br>2 sand.<br>4 lead.<br>0 | 15 | 00 | 5 | |
| | | 61 | 294 | | 11 | | 18<br>1<br>20 | 12<br>4 sand.<br>0 | 15 | 00 | 5 | |
| | | 62 | 295 | | 11 | | 18<br>1<br><br>20 | 8<br>4 sand.<br>4 lead.<br>0 | 15 | 00 | 5 | |
| | | 63 | 296 | | 11 | | 18<br>1<br>20 | 10<br>6 sand.<br>0 | 15 | 00 | 5 | |
| Jan. 18 | A. M. | 64 | 297 | | 11 | | 18<br>1<br>20 | 14<br>2 sand.<br>0 | 15 | 00 | 5 | |

TARGET.

| No. of rounds. | Range. | Deviation, right. |
|---|---|---|
| | *Yards.* | *Yards.* |
| 288 | 1,126 | 19 |
| 289 | 1,248 | 17 |
| 290 | 1,223 | 16 |
| 291 | 1,231 | 17 |
| 292 | 1,210 | 17 |
| 293 | 1,230 | 16 |
| 294 | 1,225 | 16 |
| 295 | 1,237 | 18 |
| 296 | 1,208 | 17 |
| 207 | 1,227 | 16 |

| | *Yards* |
|---|---|
| Greatest range | 1,24 |
| Least range | 1,2 |
| Dispersion in range | 12 |
| Greatest deviation from plane of fire | 1 |
| Least deviation from plane of fire | 1 |
| Lateral dispersion | [illegible] |

*Watervliet Arsenal, at Sandy Hook, N. J., January 13, 1891.*

accuracy of motar.]

| Time of flight. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|
| | Mortar mounted on new experimental steel carriage made at Watervliet Arsenal. Cannon friction primers (experimental), with modified priming, March, 1890. | |
| *Secs.*<br>7 | | Sighting shot. Range, 1,200 yards. Deviation from plane of fire, 16 yards, right. |
| Lost. | | |
| 8½ | | |
| 9 | | |
| 8 | Powder put up in two cartridges, weighing 3 and 8 ounces, respectively; the smaller one placed in chamber first.<br>Fired down the beach. Aimed at center of 1-mile target. | |
| 8 | Recoil restrained by 2½-inch rope arranged as in previous firing. Rope allowed recoil of 5 feet. | |
| 7⅘ | | |
| 8 | | |
| 8½ | | |
| 7⅗ | | |
| 8 | Fired down the beach. | |
| | Mortar sighted by Lieut. O. M. Lissak, O. D. Fall of projectile observed by Corpl. Alward, ordnance detachment. Stop watch held by Corpl. Alward, ordnance detachment.<br>Firing conducted by Lieut. O. M. Lissak, O. D., assistant proof officer. | |

TARGET.

| No. of round. | Range. | Lateral deviation from plane of fire, right. | From center of impact, longitudinal. | | From center of impact, lateral. | |
|---|---|---|---|---|---|---|
| | | | + | − | Right. | Left. |
| | *Yards.* | *Yards.* | *Yds.* | *Yds.* | *Yds.* | *Yds.* |
| 288 | 1,126 | 19 | ........ | 90.5 | 2.1 | ...... |
| 289 | 1,248 | 17 | 31.5 | ........ | 0.1 | ...... |
| 290 | 1,223 | 16 | 6.5 | ........ | ...... | 0.9 |
| 291 | 1,231 | 17 | 14.5 | ........ | 0.1 | ...... |
| 292 | 1,210 | 17 | ........ | 6.5 | 0.1 | ...... |
| 293 | 1,230 | 16 | 13.5 | ........ | ...... | 0.9 |
| 294 | 1,225 | 16 | 8.5 | ........ | ...... | 0.9 |
| 295 | 1,237 | 18 | 20.5 | ........ | 1.1 | ...... |
| 296 | 1,208 | 17 | ........ | 8.5 | 0.1 | ...... |
| 297 | 1,227 | 16 | 10.5 | ........ | ...... | 0.9 |
| | 12,165 | 169 | 105.5 | 105.5 | 3.6 | 3.6 |

| | *Yards.* |
|---|---|
| Mean range | 1,216.5 |
| Mean lateral deviation from plane of fire | 16.9 |
| Mean longitudinal deviation from center of impact | 21.1 |
| Mean lateral deviation from center of impact | 72 |

12,165÷10=1,216.5     169÷10=16.9     211÷10=21.1     7.2÷10=0.72

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1.*

[Object of firing, to tes

| Date. | | No. of series. | No. of fire. | Powder. | | Projectile. | | Elevation. | Recoil. | Wind strength and direction. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1891. | | | | | *Pounds.* | | *Lbs. Oz.* | ° ′ | *Feet.* | |
| Jan. 16 | A. M. | 65 | 298 | Du Pont's I. K. H. Lot 16. Density, 1.725. Granulation, 2.524. | 1 | Mortar shell (lot 273), specially provided for accuracy test. | 18 14<br>1 2 sand.<br>20 0 | 15 00 | ........ | From right 14 miles an hour |
| | | 66 | 299 | | 1 | | 19 4<br>12 sand.<br>20 0 | 15 00 | 6¼ | |
| | | 67 | 300 | | 1 | | 19 2<br>14 sand.<br>20 0 | 15 00 | 6 | |
| | | 68 | 301 | | 1 | | 18 15<br>1 1 sand.<br>20 0 | 15 00 | 5 | |
| | | 69 | 302 | | 1 | | 18 8<br>1 4 sand.<br>4 lead.<br>20 0 | 15 00 | 5 | |
| | | 70 | 303 | | 1 | | 18 12<br>1 4 sand.<br>20 0 | 15 00 | 5 | |
| | | 71 | 304 | | 1 | | 19 0<br>1 0 sand.<br>20 0 | 15 00 | 5 | |
| | | 72 | 305 | | 1 | | 18 14<br>1 2 sand.<br>20 0 | 15 00 | ........ | |
| | | 73 | 306 | | 1 | | 19 4<br>12 sand.<br>20 0 | 15 00 | 6 | |
| | | 74 | 307 | | 1 | | 19 2<br>14 sand.<br>20 0 | 15 00 | 6 | |
| | | 75 | 308 | | 1 | | 19 1<br>15 sand.<br>20 0 | 15 00 | 6 | |

TARGET.

| No. of round. | Range. | Deviation, right. |
|---|---|---|
| | *Yards.* | *Yards.* |
| 299 | 1,893 | 21 |
| 300 | 1,891 | 20 |
| 301 | 1,928 | 18 |
| 302 | 1,918 | 16 |
| 303 | 2,040 | 17 |
| 304 | 1,985 | 17 |
| 305 | 2,191 | 21 |
| 306 | 1,953 | 17 |
| 307 | 1,913 | 18 |
| 308 | 2,219 | 12 |

Greatest range ........................................

Least range ........................................

Dispersion in range ........................................

Greatest lateral deviation from plane of fire ..........

Least deviation from plane of fire ........................

Lateral dispersion ........................................

*Vatervliet Arsenal, at Sandy Hook, N. J., January 16, 1891.*

ccuracy of mortar.]

| Time of flight. | | Special remarks about each as effect on piece, action c mechanism, consumption oi sound of projectile in fligh ing of fragments, etc., ar logical data. |
|---|---|---|
| | Mortar mounted on new experimental steel carriage made at Watervliet Arsenal. Cannon friction primers (experimental), with spiral serrated wire, March, 1890. | |
| *Secs.*<br>9¼ | | Sighting shot. Range, 1,89 Deviation from plane of fire, right. |
| 9¾ | | |
| 9¾ | | First primer failed. |
| 10 | | |
| 10 | | |
| 10¾ | Powder put up in two cartridges of 8 ounces each.<br>Fired down the beach. Aimed at center of 1-mile target.<br>Recoil restrained by 2¼-inch rope arranged as in previous firing. Rope allows recoil of 5 feet. In rounds 298 to 300, inclusive, rope allowed recoil of 6 feet. | |
| 10¼ | | Mortar tipped forward on fac |
| 11 | | Mortar tipped forward on fac |
| 10¼ | | One strand of rope broken. |
| 11¼ | | |
| 11¼ | | Mortar tipped over on left sid |
| | Mortar sighted by Lieut. O. M. Lissak. Fall of projectile observed by Corpl. Maloney, ordnance detachment. | |

TARGET.

| No. of round. | Range. | Lateral deviation from plane of fire, right. | From center of impact, longitudinal | | From center of impact, lateral. | | |
|---|---|---|---|---|---|---|---|
| | | | + | − | Right. | Left. | |
| | *Yards.* | *Yards.* | *Yds.* | *Yds.* | *Yards.* | *Yds.* | |
| 99 | 1,893 | 21 | ...... | 100.1 | 3.3 | ...... | Mean range ........................ |
| 00 | 1,891 | 20 | ...... | 102.1 | 2.3 | ...... | Mean lateral deviation from plane of fire ........................ |
| 01 | 1,928 | 18 | ...... | 65.1 | 0.3 | ...... | |
| 02 | 1,918 | 16 | ...... | 75.1 | ........ | 1.7 | Mean longitudinal deviation from center of impact ................ |
| 03 | 2,040 | 17 | 46.9 | ...... | ........ | 0.7 | |
| 04 | 1,985 | 17 | ...... | 8.1 | ........ | 0.7 | Mean lateral deviation from center of impact ........................ |
| 05 | 2,191 | 21 | 197.9 | ...... | 3.3 | ...... | |
| 06 | 1,953 | 17 | ...... | 40.1 | ........ | 0.7 | |
| 07 | 1,913 | 18 | ...... | 80.1 | 0.3 | ...... | |
| 08 | 2,219 | 12 | 225.9 | ...... | ........ | 5.7 | |
| | 19,931 | 177 | 470.7 | 470.7 | 9.5 | 9.5 | |

19,931+10=1,993.1  177+10=17.7  941.4+10=94.14  19+10=1.9

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1, Watervliet*

[Object of firing, to test

| Date. | | No. of series. | No. of fire. | Powder. | | Projectile. | | Elevation. | Recoil. | Wind, strength and direction. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1891. | | | | | *Pounds.* | | *Lbs. Oz.* | ° ′ | *Feet.* | |
| Jan. 16 | A.M. | 76 | 309 | Du Pont's I. K. H. Lot 16. Density, 1.725. Granulation, 2,524. | 1 | Mortar shell (lot 273), specially provided for accuracy test. | 19 0<br>1 0 sand.<br>20 0 | 25 00 | 6 | From right, 14 miles an hour. |
| | | 77 | 310 | | 1 | | 19 0<br>1 0 sand.<br>20 0 | 25 00 | 6 | |
| | | 78 | 311 | | 1 | | 19 1<br>15 sand.<br>20 0 | 25 00 | 6 | |
| | | 79 | 312 | | 1 | | 18 12<br>1 4 sand.<br>20 0 | 25 00 | 6 | |
| | | 80 | 313 | | 1 | | 18 14<br>1 2 sand.<br>20 0 | 25 00 | 6 | |
| | | 81 | 314 | | 1 | | 18 11<br>1 5 sand.<br>20 0 | 25 00 | 6 | |
| | | 82 | 315 | | 1 | | 18 13<br>1 3 sand.<br>20 0 | 25 00 | 6 | |
| | | 83 | 316 | | 1 | | 18 14<br>1 2 sand.<br>20 0 | 25 00 | 6 | |
| | | 84 | 317 | | 1 | | 18 14<br>1 2 sand.<br>20 0 | 25 00 | 6 | |
| | | 85 | 318 | | 1 | | 18 13<br>1 3 sand.<br>20 0 | 25 00 | 6 | |

TARGET.

| No. of round. | Range. | Deviation, right. |
|---|---|---|
| | *Yards.* | *Yards.* |
| 309 | 2,751 | 32 |
| 310 | 2,760 | 32 |
| 311 | 2,760 | 33 |
| 312 | 2,527 | 76 |
| 313 | 2,752 | 34 |
| 314 | 2,760 | 37 |
| 315 | 2,835 | 39 |
| 316 | 2,875 | 41 |

| | *Yards.* |
|---|---|
| Greatest range | 2,875 |
| Least range | 2,527 |
| Dispersion in range | 34 |
| Greatest lateral deviation from plane of fire | 76 |
| Least deviation from plane of fire | 32 |
| Lateral dispersion | 44 |

| Time of flight. | |
|---|---|
| | Mortar mounted on new experimen made at Watervliet Arsenal. primers (experimental), with spi March, 1890. |
| *Secs.* | |
| Lost. | |
| Lost. | |
| Lost. | |
| Lost. | |
| 16 | |
| Lost. | Fired down the beach. Aimed at target.<br>Recoil restrained by 2½-inch rop previous firing. Rope allowed |
| .15 | |
| 16 | |
| Lost. | |
| 15½ | |
| | Mortar sighted by Lieut. O. M. I |

| No. of round. | Range. | Lateral deviation from plane of fire, right. | From center of impact, longitudinal. | | Fro of L |
|---|---|---|---|---|---|
| | | | + | − | Rig |
| | *Yards.* | *Yards.* | *Yds.* | *Yds.* | *Yar* |
| 309....... | 2,751 | 32 | ...... | 1.5 | .... |
| 310....... | 2,760 | 32 | 7.5 | ...... | .... |
| 311....... | 2,760 | 33 | 7.5 | ...... | .... |
| 312....... | 2,527 | 76 | ...... | 225.5 | 3 |
| 313....... | 2,752 | 34 | ...... | .5 | .... |
| 314....... | 2,760 | 37 | 7.5 | ...... | .... |
| 315....... | 2,835 | 39 | 82.5 | ...... | .... |
| 316....... | 2,875 | 41 | 122.5 | ...... | |
| | 22,020 | 324 | 227.5 | 227.5 | 3 |

22,020 ÷ 8 = 2,752.5 324 ÷

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1, Watervliet*

**[Object of firing, to test**

| Date. | | No. of series. | No. of fire. | Powder. | | Projectile. | | Elevation. | Recoil. | Wind strength and direction. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1891 | | | | | *Pounds.* | | *Lbs. Oz.* | ° ′ | *Feet.* | |
| Jan. 16 | A. M. | 86 | 319 | Du Pont's I. K. H. Lot 16. Density, 1.725. Granulation, 2.524. | 1 | Mortar shell (lot 273), specially provided for accuracy test. | 18 14<br>1 2 sand.<br>20 0 | 30 00 | 6 | From right, 14 miles an hour. |
| | | 87 | 320 | | 1 | | 18 15<br>1 1 sand,<br>20 0 | 30 00 | 6 | |
| | | 88 | 321 | | 1 | | 18 13<br>1 3 sand.<br>20 0 | 30 00 | 6 | |
| | | 89 | 322 | | 1 | | 19 0<br>1 0 sand.<br>20 0 | 30 00 | 6 | |
| | | 90 | 323 | | 1 | | 18 14<br>1 2 sand.<br>20 0 | 30 00 | 6 | |
| | | 91 | 324 | | 1 | | 18 13<br>1 3 sand.<br>20 0 | 30 00 | 6 | |
| | | 92 | 325 | | 1 | | 18 14<br>1 2 sand.<br>20 0 | 30 00 | 6 | |
| | | 93 | 326 | | 1 | | 18 13<br>1 3 sand.<br>20 0 | 30 00 | 6 | |
| | | 94 | 327 | | 1 | | 18 13<br>1 3 sand.<br>20 0 | 30 00 | 6 | |
| | | 95 | 328 | | 1 | | 18 14<br>1 2 sand.<br>20 0 | 30 00 | 6 | |

Arsenal, at Sandy Hook, N. J., from January 16, 1891—Contir

ccuracy of mortar.]

| Time of flight. | | Special re as effec mechan sound o ing of logical |
|---|---|---|
| *Secs.*<br>Lost. | Mortar mounted on new experimental mortar carriage made at Watervliet Arsenal. Cannon friction primers (experimental), with spiral serrated wire, March, 1890. | |
| Lost. | | |
| Lost. | | |
| Lost. | | First prin |
| Lost. | Fired down the beach. Aimed at center of 1-mile target.<br>Recoil restrained by 2½-inch rope arranged as in previous firing. Rope allowed recoil of 6 feet.<br>In rounds 319 to 324, inclusive, and 326 to 328, inclusive, the location of shots could not be found. | |
| 17 | | |
| 17½ | | Range, 2,9 right. |
| 17 | | |
| Lost. | | |
| 17 | | |
| | Mortar sighted by Lieut. O. M. Lissak, O. D. Fall of projectile observed by Corpl. Maloney, ordnance detachment. Stop-watch held by Corpl. Maloney, ordnance detachment.<br>Firing conducted by Lieut. O. M. Lissak, O. D., assistant proof officer. | |

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1,*

[Object of firing, to test

| Date. | | No. of series. | No. of fire. | Powder. | | Projectile. | | Elevation. | Recoil. | Wind, strength and direction. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1801. | | | | | *Pounds.* | | *Lbs. Oz.* | ° ′ | *Feet.* | |
| Jan. 20 | A. M. | 96 | 329 | Du Pont's I. K. H. Lot 16. Density, 1.725. Granulation, 2,524. | 1 | Shell (banded), experimental. Lot 249. | 19 1<br>15 sand.<br>20 0 | 45 00 | 7 | From right and rear, 18 miles an hour. |
| | | 97 | 330 | | 1 | | 19 1<br>15 sand.<br>20 0 | 45 00 | 7 | |
| | | 98 | 331 | | 1 | | 19 4<br>12 sand.<br>20 0 | 30 00 | 10 | |
| | | 99 | 332 | | 1 | | 19 2<br>14 sand.<br>20 0 | 35 00 | 12 | |
| | | 100 | 333 | | 1 | | 19 4<br>12 sand.<br>20 0 | 40 00 | 12 | |
| | | 101 | 334 | | 1 | | 19 1<br>15 sand.<br>20 0 | 40 00 | 14 | |
| | | 102 | 335 | | 1 | | 19 1<br>15 sand.<br>20 0 | 80 00 | 14 | |
| | | 103 | 336 | | 1 | | 19 1<br>15 sand.<br>20 0 | 35 00 | 14 | |
| | | 104 | 337 | | 1 | | 19 1<br>15 sand.<br>20 0 | 45 00 | 8 | |
| | | 105 | 338 | | 1 | Mortar shell (lot 273), specially provided for accuracy test. | 18 12<br>1 4 sand.<br>20 0 | 45 00 | 8 | |
| | | 106 | 339 | | 1 | | 18 13<br>1 3 sand.<br>20 0 | 45 00 | 8 | |
| | | 107 | 340 | | 1 | | 18 12<br>1 4 sand.<br>20 0 | 45 00 | 7 | |
| | | 108 | 341 | | 1 | | 18 12<br>1 4 sand.<br>20 0 | 45 00 | 7 | |
| | | 109 | 342 | | 1 | | 19 0<br>1 0 sand.<br>20 0 | 45 00 | 7 | |
| | | 110 | 343 | | 1 | | 19 0<br>1 0 sand.<br>20 0 | 45 00 | 7 | |

*atervliet Arsenal, at Sandy Hook, N. J., January 20, 1891.*

**curacy of mortar.]**

| Time of flight. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|
| *Secs.* | | |
| Lost. | Mortar mounted on new experimental steel carriage made at Watervliet Arsenal. Cannon friction primers (experimental), with spiral serrated wire, March, 1890. | Sighting shot. |
| 19 | | Sighting shot. First primer failed. |
| 22 | | Sighting shot. Three primers failed. |
| 24 | | Sighting shot. Piece of unburnt cartridge bag, not holding fire, found in muzzle. |
| 20 | | Sighting shot. |
| 23 | | Sighting shot. |
| 27 | | Sighting shot. Range, 3,181 yards; deviation, 34 yards, left. |
| Lost. | Direction given by wooden strip nailed on platform.<br>Fired down the beach.<br>The deviation is taken from a line parallel to the line of fire. | Sighting shot. |
| Lost. | | Sighting shot. Mortar turned over. Service rammer broken. |
| 24 | | |
| 26 | | |
| 26 | | |
| 27 | | Range, 3,355 yards; deviation, 5 yards, right. |
| 27 | | |
| Lost. | | Range, 3,307 yards; deviation, 8 yards, left. |

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1, Watervliet*

[Object of firing, to test

| Date. | | No. of series. | No. of fire. | Powder. | | Projectile. | | Elevation. | Recoil. | Wind strength and direction. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1891. | | | | | *Pounds.* | | *Lbs. Oz.* | ° ′ | *Feet.* | |
| Jan. 20 | A. M. | 111 | 344 | Du Pont's I. K. H. Lot 16. Density, 1.726. Granulation, 2.524″ | 1 | Mortar shell (lot 273), specially provided for accuracy test. | 18 14<br>1 2 sand.<br>20 0 | 45 00 | 7 | From right and rear, 13 miles an hour. |
| | | 112 | 345 | | 1 | | 18 11<br>1 5 sand.<br>20 0 | 45 00 | 7 | |
| | | 113 | 346 | | 1 | | 19 0<br>1 0 sand.<br>20 0 | 45 00 | 7 | |
| | | 114 | 347 | | 1 | | 18 12<br>1 4 sand.<br>20 0 | 45 00 | 7 | |
| | | 115 | 348 | | 1 | Mortar shell (lot 275), specially provided for accuracy test. | 18 15<br>1 1 sand.<br>20 0 | 40 00 | 10 | |
| | | 116 | 349 | | 1 | | 18 13<br>1 3 sand.<br>20 0 | 40 00 | 10 | |
| | | 117 | 350 | | 1 | | 18 15<br>1 1 sand.<br>20 0 | 40 00 | 10 | |
| | | 118 | 351 | | 1 | | 18 15<br>1 1 sand.<br>20 0 | 40 00 | 10 | |
| | | 119 | 352 | | 1 | | 19 2<br>14 sand.<br>20 0 | 40 00 | 10 | |
| | | 120 | 353 | | 1 | | 18 13<br>1 3 sand.<br>20 0 | 40 00 | 10 | |
| | | 121 | 354 | | 1 | | 19 0<br>1 0 sand.<br>20 0 | 40 00 | 10 | |
| | | 122 | 355 | | 1 | | 18 13<br>1 3 sand.<br>20 0 | 40 00 | 10 | |
| | | 123 | 356 | | 1 | | 18 14<br>1 2 sand.<br>20 0 | 40 00 | 10 | |
| | | 124 | 357 | | 1 | | 18 15<br>1 1 sand.<br>20 0 | 40 00 | 10 | |

*rsenal, at Sandy Hook, N. J., January 20, 1891*—Continued.

**ccuracy of mortar.]**

| Time of flight. Secs. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|
| | Mortar mounted on new experimental steel carriage made at Watervliet Arsenal. Cannon friction primers (experimental), with spiral serrated wire, March, 1890. | |
| Lost. | | Range, 3,345 yards; deviation, 3 yards, right. |
| Lost. | | Range, 3,378 yards; deviation, 6 yards, right. |
| Lost. | | Range, 3,449 yards; deviation, 18 yards, right. |
| 25 | | |
| 26 | | Range, 3,494 yards; deviation, 5 yards, right. |
| Lost. | | |
| 25 | | |
| Lost. | The deviation is taken from a line parallel to the line of fire.<br>Direction given by wooden strip nailed to platform.<br>Fired down the beach. | |
| Lost. | | |
| 23 | | |
| 24 | | |
| Lost. | | |
| Lost. | | |
| Lost. | | |
| | Fall of projectile observed by Corpl. Maloney, ordnance detachment. | |

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1, Watervliet*

[Object of firing, to test

| Date. | | No. of series. | No. of fire. | Powder. | | Projectile. | | Elevation. | Recoil. | Wind strength and direction |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1891. | | | | | *Pounds.* | | *Lbs. Oz.* | ° ′ | *Feet.* | |
| Jan. 20 | P. M. | 125 | 358 | Du Pont's I. K. H. Lot 16. Density, 1.725. Granulation, 2,524. | 1 | Shell (banded), experimental. Lot No. 249. | 19 1<br>15 sand.<br>20 0 | 35 00 | 12 | From right and rear, 13 miles an hour. |
| | | 126 | 359 | | 1 | | 18 14<br>1 2 sand.<br>20 0 | 35 00 | 6 | |
| | | 127 | 360 | | 1 | Mortar shell, lot (275), specially provided for accuracy test. | 18 14<br>1 2 sand.<br>20 0 | 35 00 | 6 | |
| | | 128 | 361 | | 1 | | 18 1<br>1 15 sand.<br>20 0 | 35 00 | 5 | |
| | | 129 | 362 | | 1 | | 18 12<br>1 4 sand.<br>20 0 | 35 00 | 6 | |
| | | 130 | 363 | | 1 | | 18 13<br>1 3 sand.<br>20 0 | 35 00 | 6 | |
| | | 131 | 364 | | 1 | | 19 1<br>0 15 sand.<br>20 0 | 35 00 | 6 | |
| | | 132 | 365 | | 1 | | 19 0<br>1 0 sand.<br>20 0 | 35 00 | 6 | |
| | | 133 | 366 | | 1 | | 18 11<br>0 5 sand.<br>1 0 lead.<br>20 0 | 35 00 | 6 | |
| | | 134 | 367 | | 1 | | 18 15<br>1 1 sand.<br>20 0 | 35 00 | 6 | |
| | | 135 | 368 | | 1 | | 18 10<br>0 6 lead.<br>1 0 sand.<br>20 0 | 35 00 | 6 | |
| | | 136 | 369 | | 1 | | 19 1<br>0 15 sand.<br>20 0 | 30 00 | 6 | |

*Arsenal, at Sandy Hook, N. J., January 20, 1891*—Continued.

accuracy of mortar.]

| Time of flight. Secs. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|
| Lost. | Cannon friction primers (experimental), with spiral serrated wire, March, 1890.<br>Direction given by wooden strip nailed to platform.<br>Fired down the beach.<br>The deviation is taken from a line parallel to the line of fire.<br>Recoil restrained by 2½-inch rope arranged as in previous firing. Rope allowed recoil of 6 feet. | Sighting shot. Range, 3,281 yards; deviation, 35 yards, left. |
| Lost. | | Range, 3,263 yards; deviation, 35 yards, left. |
| Lost. | | Range, 3,249 yards; deviation, 49 yards, left. |
| Lost. | | Vent shield bent by discharge; straightened by hand. Range, 3,260 yards; deviation, 38 yards, left. |
| Lost. | | |
| Lost. | | |
| Lost. | | Range, 3,306 yards; deviation, 29 yards, left. |
| Lost. | | Range, 3,190 yards; deviation, 44 yards left. |
| Lost. | | |
| Lost. | | |
| Lost. | | |
| Lost. | | Range, 3,187 yards; deviation, 60 yards, left. |

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1,*

[Object of firing, to test

| Date. | | No. of series. | No. of fire. | Powder. | | Projectile. | | Elevation. | Recoil. | Wind strength and direction |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1891. | | | | | *Pounds.* | | *Lbs. Oz.* | ° ′ | *Feet.* | |
| Jan. 21 | A. M. | 137 | 370 | Du Pont's I. K. H. Lot 16. Density, 1.725. Granulation, 2,524. | 1 | Shell (banded), experimental. Lot 249. | 19 0<br>1 0 sand.<br>20 0 | 30 00 | 6 | From right and rear, 13 miles an hour. |
| | | 138 | 371 | | 1 | | 19 3<br>13 sand.<br>20 0 | 30 00 | 6 | |
| | | 139 | 372 | | 1 | | 19 2<br>14 sand.<br>20 0 | 30 00 | 6 | |
| | | 140 | 373 | | 1 | | 19 2<br>14 sand.<br>20 0 | 30 00 | 6 | |
| | | 141 | 374 | | 1 | | 19 2<br>14 sand.<br>20 0 | 30 00 | 6 | |
| | | 142 | 375 | | 1 | | 19 3<br>13 sand.<br>20 0 | 30 00 | 6 | |
| | | 143 | 376 | | 1 | | 19 3<br>13 sand.<br>20 0 | 30 00 | 6 | |
| | | 144 | 377 | | 1 | | 19 4<br>12 sand.<br>20 0 | 30 00 | 6 | |
| | | 145 | 378 | | 1 | | 18 13<br>1 3 sand.<br>20 0 | 30 00 | 6 | |

*Watervliet Arsenal, at Sandy Hook, N. J., January 21, 1891.*

accuracy of mortar.]

| Time of flight. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|
| *Secs.* | Cannon friction primers (experimental), with spiral serrated wire, March, 1890. | |
| Lost. | The deviation is taken from a line parallel to the line of fire.<br>Fired down the beach.<br>In the rounds where no range is recorded the shots were lost. | Range, 3,176 yards; deviation, 60 yards, left. |
| Lost. | | Range, 3,144 yards; deviation, 63 yards, left. |
| Lost. | | First primer failed; strand of rope broken. |
| Lost. | | Range, 3,267 yards; deviation, 45 yards, left. |
| Lost. | | Range, 3,179 yards; deviation, 67 yards, left. |
| Lost. | | First primer failed; range, 3,107 yards; deviation, 66 yards, left. |
| Lost. | | |
| Lost. | | |
| Lost. | | Range, 3,073 yards; deviation, 58 yards, left. |
| | Mortar sighted by Lieut. O. M. Lissak, O. D.<br>Fall of projectile observed by Corpl. Alward, ordnance detachment.<br>Firing conducted by Lieut. O. M. Lissak, O. D., assistant proof officer.<br>Mortar star gauged after round 378, January 30, 1891, by Lieut. O. M. Lissak, O. D. | |

*Record of firing with 3.6-inch B. L. field mortar (steel,) No.*

[Object of firing, to test

| Date. | | No. of series. | No. of fire. | Powder. Kind. | Powder. Weight. | Projectile. Kind. | Projectile. Weight. Lbs. | Projectile. Weight. Oz. | Elevation. ° | Elevation. ' | Reco Ft. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Pounds.* | | *Lbs.* | *Oz.* | | | |
| 1891. Feb. 5 | A. M. | ...... | 379 | Du Pont's I. K. H. Lot 16. Density, 1.725. Granulation, 2.524. | 1 | Shell (banded), experimental. Lot 249. | 19<br><br>20 | 3<br>13 sand.<br>0 | 30 | 00 | 5 |
| | | ...... | 380 | | 1 | | 19<br><br>20 | 3<br>13 sand.<br>0 | 35 | 00 | 5 |
| | | ...... | 381 | | 1 | | 19<br><br>20 | 3<br>13 sand.<br>0 | 35 | 00 | 5 |
| | | ...... | 382 | | 1 | | 19<br>1<br>20 | 2<br>14 sand.<br>0 | 35 | 00 | 5 |
| | | ...... | 383 | | 1 | | 19<br><br>20 | 5<br>11 sand.<br>0 | 35 | 00 | 5 |
| | | 146 | 384 | | 1 | Mortar shell (rebanded), specially provided for accuracy test. | 20 | 0 including sand. | 35 | 00 | 5 |
| | | 147 | 385 | | 1 | | 20 | 0 including sand. | 35 | 00 | 5 |
| | | 148 | 386 | | 1 | | 20 | 0 including sand. | 35 | 00 | 5 |
| | | 149 | 387 | | 1 | | 20 | 0 including sand. | 35 | 00 | 5 |
| | | 150 | 388 | | 1 | | 20 | 0 including sand. | 35 | 00 | 5 |
| | | 151 | 389 | | 1 | | 20 | 0 including sand. | 35 | 00 | 5 |
| | | 152 | 390 | | 1 | | 20 | 0 including sand. | 35 | 00 | 4 |
| | | 153 | 391 | | 1 | | 20 | 0 including sand. | 35 | 00 | 5 |
| | | 154 | 392 | | 1 | | 20 | 0 including sand. | 35 | 00 | 5 |
| | | 155 | 393 | | 1 | | 20 | 0 including sand. | 35 | 00 | 5 |

TARGET.

| No. of round. | Range. | Deviation, right. |
|---|---|---|
| | *Yards.* | *Yards.* |
| 384 | 3,061 | 46 |
| 385 | 3,057 | 43 |
| 386 | 3,086 | 41 |
| 387 | 3,140 | 41 |
| 388 | 2,975 | 45 |
| 389 | 3,099 | 44 |
| 390 | 3,121 | 43 |
| 391 | 3,096 | 38 |
| 392 | 3,055 | 36 |
| 393 | 3,135 | 45 |

Greatest range
Least range

Dispersion in range

Greatest deviation from plane of fire
Least deviation from plane of fire

Lateral dispersion

*Watervliet Arsenal, at Sandy Hook, N. J., February 5, 1891.*

accuracy of mortar.]

| Wind, strength and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of power, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|
| | Mortar mounted on experimental steel carriage made at Watervliet Arsenal. Cannon friction primers (experimental), with spiral serrated wire, March, 1890. | |
| From front and right, 9 miles an hour. | Direction given by wooden strip nailed on platform.<br>Fired down the beach.<br>Recoil restrained by 2½-inch rope arranged as in previous firing. Rope allowed recoil of 5 feet and 2 inches.<br>Vent shield bent by discharge. | Sighting shot. Range about 2,700 yards.<br>Sighting shot. Struck 200 feet to left, and 100 feet in rear of 3,000-yards target.<br>Sighting shot. Struck 250 yards in rear of target and 18 feet above high-water mark. Line of fire moved farther to the right.<br>Sighting shot. Struck 200 feet in rear and 20 feet to right of 3,000-yards target. Line of fire moved to the left.<br>Sighting shot. Range, 3,047 yards. Deviation from line of fire, 39 yards, right. |
| | Mortar sighted by Lieut. O. M. Lissak, O. D. Fall of projectile observed by Lieut. W. W. Gibson, O. D. | |

TARGET.

| No. of round. | Range. | Lateral deviation from plane of fire, right. | From center of impact, longitudinal. | | From center of impact, lateral. | |
|---|---|---|---|---|---|---|
| | | | + | − | Right. | Left. |
| | *Yards.* | *Yards.* | *Yds.* | *Yds.* | *Yards.* | *Yds.* |
| 384 | 3,061 | 46 | ...... | 21.5 | 3.8 | ...... |
| 385 | 3,057 | 43 | ...... | 25.5 | .8 | ...... |
| 386 | 3,086 | 41 | 3.5 | ...... | ........ | 1.2 |
| 387 | 3,140 | 41 | 57.5 | ...... | ........ | 1.2 |
| 388 | 2,975 | 45 | ...... | 107.5 | 2.8 | ...... |
| 389 | 3,099 | 44 | 16.5 | ...... | 1.8 | ...... |
| 390 | 3,121 | 43 | 38.5 | ...... | .8 | ...... |
| 391 | 3,096 | 38 | 13.5 | ...... | ........ | 4.2 |
| 392 | 3,055 | 36 | ...... | 27.5 | ........ | 6.2 |
| 393 | 3,135 | 45 | 52.5 | ...... | 2.8 | ...... |
| | 30,825 | 422 | 182.0 | 182.0 | 12.8 | 12.8 |

| | *Yards.* |
|---|---|
| Mean range | 3,082.5 |
| Mean lateral deviation from plane of fire | 42.2 |
| Mean longitudinal deviation from center of impact | 36.4 |
| Mean lateral deviation from center of impact | 2.56 |

30,825 + 10 = 3,082.5 422 + 10 = 42.2 364 + 10 = 36.4 25.6 + 10 = 2.53

*Record of firing with 3.6-inch B. L. field mortar (steel), No 1, Watervliet*

[Object of firing, to test

| Date. | | No. of series. | No. of fire. | Powder. | | Projectile. | | Elevation. | Recoil. | Wind, strength and direction. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Kind. | Weight. | Kind. | Weight. | | | |
| | | | | | *Pounds.* | | *Lbs. Oz.* | ° ′ | *Ft. In.* | |
| 1891.<br>Feb. 5 | P. M. | ...... | 394 | Du Pont's I. K. H. Lot 16. Density, 1.725. Granulation, 2,524. | 1 | Shell (banded), experimental. Lot 249. | 19 1<br>15 sand.<br>20 0 | 40 00 | 5 2 | From front and right, 12 miles an hour. |
| | | 156 | 395 | | 1 | | 19 1<br>15 sand.<br>20 0 | 40 00 | 5 2 | |
| | | 157 | 396 | | 1 | | 19 1<br>15 sand.<br>20 0 | 40 00 | 5 2 | |
| | | 158 | 397 | | 1 | | 19 1<br>15 sand.<br>20 0 | 40 00 | 5 2 | |
| | | 159 | 398 | | 1 | | 19 1<br>15 sand.<br>20 0 | 40 00 | 5 2 | |
| | | 160 | 399 | | 1 | | 19 2<br>14 sand.<br>20 0 | 40 00 | 5 2 | |
| | | 161 | 400 | | 1 | | 19 3<br>13 sand.<br>20 0 | 40 00 | 5 2 | |
| | | 162 | 401 | | 1 | | 19 1<br>15 sand,<br>20 0 | 40 00 | 5 2 | |
| | | 163 | 402 | | 1 | | 19 2<br>14 sand.<br>20 0 | 40 00 | 5 2 | |
| | | 164 | 403 | | 1 | | 19 3<br>13 sand.<br>20 0 | 40 00 | 5 2 | |
| | | 165 | 404 | | 1 | | 19 1<br>15 sand.<br>20 0 | 40 00 | 5 2 | |

TARGET.

| No. of round. | Range. | Deviation, right. |
|---|---|---|
| | *Yards.* | *Yards.* |
| 395 | 3, 333 | 56 |
| 396 | 3, 146 | 42 |
| 397 | 3, 118 | 42 |
| 398 | 3, 135 | 46 |
| 399 | 3, 179 | 43 |
| 400 | 3, 094 | 37 |
| 401 | 3, 110 | 35 |
| 402 | 3, 118 | 49 |
| 403 | 3, 117 | 47 |
| 404 | 3, 291 | 46 |

| | Yards. |
|---|---|
| Greatest range | 3,333 |
| Least range | 3,094 |
| Dispersion in range | 239 |
| Greatest deviation from plane of fire | 56 |
| Least deviation from plane of fire | 35 |
| Lateral dispersion | 21 |

*Arsenal, at Sandy Hook, N. J., February 5, 1891*—Continued.

accuracy of mortar.]

| | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|
| Mortar mounted on experimental steel carriage made at Watervliet Arsenal. Cannon friction primers (experimental), with spiral serrated wire, March, 1890. | Sighting shot. Range, 3,167 yards; deviation, 45 yards, right. |
| Fired down the beach.<br>Recoil restrained by 2½-inch rope arranged as in previous firing. Rope allowed recoil of 5 feet 2 inches. | |
| Mortar sighted by Lieut. O. M. Lissak, O. D. Fall of projectile observed by Lieut. W. W. Gibson, O.D. Firing conducted by Lieut. O. M. Lissak, O. D., assistant proof officer. | |

TARGET.

| No. of round. | Range. | Lateral deviation from plane of fire, right. | From center of impact, longitudinal. | | From center of impact, lateral. | |
|---|---|---|---|---|---|---|
| | | | + | — | Right. | Left. |
| | *Yards.* | *Yards.* | *Yds.* | *Yds.* | *Yards.* | *Yds.* |
| 395...... | 3,333 | 56 | 168.9 | ...... | 11.7 | ...... |
| 396...... | 3,146 | 42 | ...... | 18.1 | ........ | 2.3 |
| 397...... | 3,118 | 42 | ...... | 46.1 | ........ | 2.3 |
| 398...... | 3,135 | 46 | ...... | 29.1 | 1.7 | ...... |
| 399...... | 3,179 | 43 | 14.9 | ...... | ........ | 1.3 |
| 400...... | 3,094 | 37 | ...... | 70.1 | ........ | 7.3 |
| 401...... | 3,110 | 35 | ...... | 54.1 | ........ | 9.3 |
| 402...... | 3,118 | 49 | ...... | 46.1 | 4.7 | ...... |
| 403...... | 3,117 | 47 | ...... | 47.1 | 2.7 | ...... |
| 404...... | 3,291 | 46 | 126.9 | ...... | 1.7 | ...... |
| | 31,641 | 443 | 310.7 | 310.7 | 22.5 | 22.5 |

| | *Yards.* |
|---|---|
| Mean range.................................. | 3,164.1 |
| Mean lateral deviation from plane of fire.................................. | 44.3 |
| Mean longitudinal deviation from center of impact.................................. | 62.14 |
| Mean lateral deviation from center of impact.................................. | 4.5 |

31,641 ÷ 10 = 3,164.1 443 ÷ 10 = 44.3 621.4 ÷ 10 = 62.14 45 ÷ 10 = 4.5

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1.*

[Object of firing, to test

| Date. | | No. of series. | No. of fire. | Powder. | | Projectile. | | Elevation. | Recoil. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Kind. | Weight. | Kind. | Weight. | | |
| 1891. | | | | | *Pounds.* | | *Lbs. Oz.* | ° ′ | *Feet.* |
| Feb. 10 | A. M. | ...... | 405 | Du Pont's I. K. H. Lot 16. Density 1.725. Granulation, 2,524. | 1 | Shell (banded), experimental. Lot 249. | 19 4<br>12 sand.<br>20 0 | 45 00 | 15 |
| | | ...... | 406 | | 1 | | 19 0<br>1 0 sand.<br>20 0 | 30 00 | 7 |
| | | 166 | 407 | | 1 | Mortar shell (rebanded), specially provided for accuracy test. | 20 0 including sand. | 30 00 | 7 |
| | | 167 | 408 | | 1 | | 20 0 including sand. | 30 00 | 7 |
| | | 168 | 409 | | 1 | | 20 0 including sand. | 30 00 | 7 |
| | | 169 | 410 | | 1 | | 20 0 including sand. | 30 00 | 7 |
| | | 170 | 411 | | 1 | | 20 0 including sand. | 30 00 | 7 |
| | | 171 | 412 | | 1 | | 20 0 including sand. | 30 00 | 7 |
| | | 172 | 413 | | 1 | | 20 0 including sand. | 30 00 | 7 |
| | | 173 | 414 | | 1 | | 20 0 including sand. | 30 00 | 7 |
| Feb. 10. | P. M. | 174 | 415 | | 1 | | 20 0 including sand. | 30 00 | 7 |
| | | 175 | 416 | | 1 | | 20 0 including sand. | 30 00 | 7 |

TARGET.

| No. of rounds. | Range. | Deviation, right. |
|---|---|---|
| | *Yards.* | *Yards.* |
| 407 | 3,074 | 25 |
| 408 | 2,960 | 37 |
| 409 | 2,976 | 42 |
| 410 | 2,977 | 43 |
| 411 | 3,054 | 53 |
| 412 | 2,933 | 16 |
| 413 | 2,947 | 42 |
| 414 | 3,019 | 27 |
| 415 | 3,072 | 18 |
| 416 | 2,991 | 31 |

| | *Yards.* |
|---|---|
| Greatest range | 3,074 |
| Least range | 2,933 |
| Dispersion in range | 141 |
| Greatest deviation from plane of fire | 53 |
| Least deviation from plane of fire | 16 |
| Lateral dispersion | 37 |

*Watervliet Arsenal, at Sandy Hook, N. J., February 10, 1891.*

accuracy of mortar.]

| Wind, strength and direction. | Time of flight. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|
| | | Mortar mounted on new experimental steel carriage made at Watervliet Arsenal. Cannon friction primers (experimental), with spiral serrated wire, March, 1890. | |
| | *Secs.* | | |
| From rear, 23 miles an hour. | ........ | | Sighting shot. Location of shell could not be found. Recoil unrestrained. |
| | ........ | | Sighting shot. Range, 3,018 yards; deviation, right, 37 yards. |
| | Lost. | | |
| | Lost. | Powder put up in two cartridges of 8 ounces each.<br>Fired down the beach.<br>Recoil restrained by 2½-inch rope arranged as in previous firing. Rope allowed recoil of 7 feet. | |
| | 19 | | Two primers failed. |
| | 19 | | |
| | 19½ | | |
| | 19 | | |
| | 19 | | |
| | 19½ | | |
| | (?) 19½ | | |
| | Lost. | Mortar sighted by Lieut. O. M. Lissak, O. D. Fall of projectile observed by Lieut. W. W. Gibson, O. D. | Vent shield broken. |

### TARGET.

| No. of round. | Range. | Lateral deviation from plane of fire, right. | From center of impact, longitudinal. | | From center of impact, lateral. | |
|---|---|---|---|---|---|---|
| | | | + | − | Right. | Left. |
| | *Yards.* | *Yards.* | *Yds.* | *Yds.* | *Yards.* | *Yds.* |
| 407 | 3,074 | 25 | 73.7 | ...... | ........ | 8.4 |
| 408 | 2,960 | 37 | ...... | 40.3 | 3.6 | ...... |
| 409 | 2,976 | 42 | ...... | 24.3 | 8.6 | ...... |
| 410 | 2,977 | 43 | ...... | 23.3 | 9.6 | ...... |
| 411 | 3,054 | 53 | 53.7 | ...... | 19.6 | ...... |
| 412 | 2,933 | 16 | ...... | 67.3 | ........ | 17.4 |
| 413 | 2,947 | 42 | ...... | 58.3 | 8.6 | ...... |
| 414 | 3,019 | 27 | 18.7 | ...... | ........ | 6.4 |
| 415 | 3,072 | 18 | 71.7 | ...... | ........ | 15.4 |
| 416 | 2,991 | 31 | ...... | 9.3 | ........ | 2.4 |
| | 30,003 | 334 | 217.8 | 217.8 | 50.0 | 50.0 |

| | *Yards.* |
|---|---|
| Mean range | 3,000.3 |
| Mean lateral deviation from plane of fire | 33.4 |
| Mean longitudinal deviation from center of impact | 43.56 |
| Mean lateral deviation from center of impact | 10 |

30,003 ÷ 10 = 3000.3    334 ÷ 10 = 33.4    435.6 ÷ 10 = 43.56    100 ÷ 10 = 10

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1, Watervli*

[Object of firing, to test

| Date. | | No. of series. | No. of fire. | Powder. | | Projectile. | | Elevation. | Recoil. | Wind strength and direction. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1891. | | | | | *Pounds.* | | *Lbs. Oz.* | ° ' | *Feet.* | |
| Feb. 10 | P. M. | ...... | 417 | Du Pont's I. K. H. Lot 16. Density, 1.725. Granulation, 2,524. | 1 | Shell (banded), experimental. Lot 249. | 19 2<br>14 sand.<br>20 0 | 35 00 | 7 | From rear, 22 miles an hour. |
| | | ...... | 418 | | 1 | | 19 1<br>15 sand.<br>20 0 | 35 00 | 7 | |
| | | ...... | 419 | | 1 | | 19 3<br>13 sand.<br>20 0 | 35 00 | 7 | |
| | | ...... | 420 | | 1 | | 19 2<br>14 sand.<br>20 0 | 35 00 | 7 | |
| | | ...... | 421 | | 1 | | 19 1<br>15 sand.<br>20 0 | 35 00 | 7 | |
| | | ...... | 422 | | 1 | | 19 2<br>14 sand.<br>20 0 | 25 00 | 7 | |
| | | 176 | 423 | | 1 | | 19 1<br>15 sand.<br>20 0 | 25 00 | 7 | |
| | | 177 | 424 | | 1 | | 19 3<br>13 sand.<br>20 0 | 25 00 | 7 | |
| | | 178 | 425 | | 1 | | 19 2<br>14 sand.<br>20 0 | 25 00 | 7 | |
| | | 179 | 426 | | 1 | | 19 3<br>13 sand.<br>20 0 | 25 00 | 7 | |
| | | 180 | 427 | | 1 | | 19 1<br>15 sand.<br>20 0 | 25 00 | 7 | |
| | | 181 | 428 | | 1 | | 19 3<br>13 sand.<br>20 0 | 25 00 | 7 | |

*Arsenal, at Sandy Hook, N. J., February 10, 1891*—Continued.

accuracy of mortar.]

| Time of flight. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|
| *Secs.* | Mortar mounted on new experimental steel carriage made at Watervliet Arsenal. Cannon friction primers (experimental), with spiral serrated wire, March, 1890. | |
| ........ | | Sighting shot. Location of shell could not be found. |
| ........ | | Sighting shot. Location of shell could not be found. |
| ........ | | Sighting shot. Location of shell could not be found. |
| ........ | | Line of fire moved to the left. Sighting shot. Location of shell could not be found. |
| ........ | | Line of fire moved to the right. Sighting shot. Range 2,749 yards; deviation right, 15 yards. |
| 16 | | Sighting shot. Location of shell could not be found. |
| 17 | Powder put up in two cartridges of 8 ounces each. Fired down the beach.<br>Recoil restrained by 2½-inch probe, arranged as in previous firing. Rope allowed recoil of 7 feet. | |
| 16½ | | |
| 16¼ | | Rope slipped off iron bar. Mortar turned over. |
| 16¾ | | |
| 16½ | | |
| 16½ | | |

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1, Watervliet*

[Object of firing, to test

| Date. | | No. of series. | No. of fire. | Powder. | | Projectile. | | Elevation. | Recoil. | Wind, strength and direction. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1891. | | | | | *Pounds.* | | *Lbs. Oz.* | ° ′ | *Feet.* | |
| Feb. 10 | P.M.. | 182 | 429 | Du Pont's I. K. H. Lot 16. Density, 1.725. Granulation, 2,524. | 1 | Shell (banded), experimental. Lot 249. | 19 4<br>12 sand.<br>20 0 | 25 00 | 7 | From rear, 22 miles an hour. |
| | | 183 | 430 | | 1 | | 19 2<br>14 sand.<br>20 0 | 25 00 | 7 | |
| | | 184 | 431 | | 1 | | 19 1<br>15 sand.<br>20 0 | 25 00 | 7 | |
| | | 185 | 432 | | 1 | | 19 2<br>14 sand.<br>20 0 | 25 00 | 7 | |

TARGET.

| No. of round. | Range. | Deviation from plane of fire. | |
|---|---|---|---|
| | | Right. | Left. |
| | *Yards.* | *Yards.* | *Yards.* |
| 423 | 2,718 | 2 | ........ |
| 424 | 2,759 | 2 | ........ |
| 425 | 2,706 | 3 | ........ |
| 426 | 2,724 | ........ | 4 |
| 427 | 2,764 | 1 | ........ |
| 428 | 2,674 | 4 | ........ |
| 429 | 2,648 | ........ | 2 |
| 430 | 2,703 | 2 | ........ |
| 431 | 2,710 | ........ | 1 |
| 432 | 2,687 | 11 | ........ |

| | *Yards.* |
|---|---|
| Greatest range | 2,76 |
| Least range | 2,64 |
| **Dispersion in range** | 116 |
| Greatest deviation right | 11 |
| Greatest deviation left | 4 |
| **Lateral dispersion** | 15 |

*Arsenal, at Sandy Hook, N. J., February 10, 1891*—Continued.

accuracy of mortar.]

| Time of flight. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|
| | Mortar mounted on new experimental steel carriage made at Watervliet Arsenal. Cannon friction primers (experimental), with spiral serrated wire, March, 1890. | |
| *Secs.*<br>16¼ | | |
| 16½ | | |
| Lost. | Fired down the beach. | |
| 16¼ | | |
| | Stop watch held by Corpl. Freeman, ordnance detachment. Mortar sighted by Lieut. O. M. Lissak, O. D Fall of projectile observed by Lieut. W. W. Gibson, O. D.<br>Firing conducted by Lieut. O. M. Lissak, O. D., assistant proof officer. | |

## TARGET.

| No. of round. | Range. | Lateral deviation from plane of fire. | | From center of impact, longitudinal. | | From center of impact, lateral. | | |
|---|---|---|---|---|---|---|---|---|
| | | Right. | Left. | + | − | Right. | Left. | |
| | *Yards.* | *Yards.* | *Yards.* | *Yards.* | *Yards.* | *Yards.* | *Yards.* | *Yards.* |
| 423 | 2,718 | 2 | | 8.7 | | .2 | | Mean range 2,709.3 |
| 424 | 2,759 | 2 | | 49.7 | | .2 | | Mean lateral deviation from plane of fire, right 1.8 |
| 425 | 2,706 | 3 | | | 8.3 | 1.2 | | |
| 426 | 2,724 | | 4 | 14.7 | | | 5.8 | Mean longitudinal deviation from center of impact 25.7 |
| 427 | 2,764 | 1 | | 54.7 | | | .8 | |
| 428 | 2,674 | 4 | | | 35.3 | 2.2 | | Mean lateral deviation from center of impact 2.64 |
| 429 | 2,648 | | 2 | | 61.3 | | 3.8 | |
| 430 | 2,703 | 2 | | | 6.3 | .2 | | |
| 431 | 2,710 | | 1 | .7 | | | 2.8 | |
| 432 | 2,687 | 11 | | | 22.3 | 9.2 | | |
| | 27,093 | 25 | 7 | 128.5 | 128.5 | 13.2 | 13.2 | |

27,093 + 10 = 2,709.3  25 — 7 = 18 + 10 = 1.8  257 + 10 = 25.7  26.4 + 10 = 2.64

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1,*

[Object of firing, to test

| Date. | | No. of series. | No. of fire. | Powder. | | Projectile. | | Elevation. | Fuse. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Kind. | Weight. | Kind. | Weight. | | |
| 1891. | | | | | *Pounds.* | | *Lbs. Oz.* | ° ′ | |
| Feb. 11 | A. M. | ...... | 433 | Du Pont's I. K. H. Lot 16. Density, 1.725. Granulation, 2,524 | 1 | Shell (banded), experimental. Lot 249. | 19 2<br>6 lead.<br>8 powder, bursting charge.<br>20 0 | 45 00 | Hotchkiss base. Purcussion fuse (small). |
| | | ...... | 434 | | 1 | | 19 5<br>3 lead.<br>8 powder, bursting charge.<br>20 0 | 45 00 | |
| | | ...... | 435 | | 1 | | 19 1<br>15 sand.<br>20 0 | 45 00 | ...... |
| | | 186 | 436 | | 1 | Mortar shell (rebanded), specially provided for accuracy test. | 20 0 including sand. | 45 00 | ...... |
| | | 187 | 437 | | 1 | | 20 0 including sand. | 45 00 | ...... |
| | | 188 | 438 | | 1 | | 20 0 including sand. | 45 00 | ...... |
| | | 189 | 439 | | 1 | | 20 0 including sand. | 45 00 | ...... |
| | | 190 | 440 | | 1 | | 20 0 including sand. | 45 00 | ...... |
| | | 191 | 441 | | 1 | | 20 0 including sand. | 45 00 | ...... |
| | | 192 | 442 | | 1 | | 20 0 including sand. | 45 00 | ...... |
| | | 193 | 443 | | 1 | | 20 0 including sand. | 45 00 | ...... |
| | | 194 | 444 | | 1 | | 20 0 including sand. | 45 00 | ...... |
| | | 195 | 445 | | 1 | | 20 0 including sand. | 45 00 | ...... |

TARGET.

| No. of round. | Range. | Deviation, right. |
|---|---|---|
| | *Yards.* | *Yards.* |
| 436 | 3,301 | 90 |
| 437 | 3,257 | 91 |
| 438 | 3,363 | 100 |
| 439 | 3,253 | 98 |
| 440 | 3,140 | 94 |
| 441 | 3,418 | 95 |
| 442 | 3,307 | 90 |
| 443 | 3,258 | 89 |
| 444 | 3,224 | 101 |
| 445 | 3,298 | 100 |

| | *Yards* |
|---|---|
| Greatest range | 3,413 |
| Least range | [illegible] |
| Dispersion in range | [illegible] |
| Greatest deviation from plane of reference | [illegible] |
| Least deviation from plane of reference | [illegible] |
| Lateral dispersion | 12 |

*Watervliet Arsenal, at Sandy Hook, N. J., February 11, 1891.*

accuracy of mortar.]

| Recoil. | Wind, strength and direction. | Time of flight. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|---|
| | | | Mortar mounted on new experimental steel carriage made at Watervliet Arsenal. Cannon friction primers (experimental), with spiral serrated wire, March, 1890. | |
| *Feet.* | | *Secs.* | | |
| 3 | From rear, 15 miles an hour. | 26 (Seen.) | Fired down the beach.<br>Recoil restrained by 2¼-inch rope, arranged as in previous firing. Rope allowed recoil of 3 feet.<br>Powder put up in two cartridges of 8 ounces each. | Sighting shot. First primer failed. Shell did not burst. |
| 8 | | 25¾ (Heard.) | | Sighting shot. Shell did not burst. |
| 3 | | 25¾ (Heard.) | | Sighting shot. Location of shell could not be found. |
| 3 | | Lost. | | |
| 3 | | Lost. | | |
| 3 | | Lost. | | |
| 3 | | Lost. | | |
| 3 | | 24¾ (Seen.) | | |
| 3 | | Lost. | | Breechblock closed with difficulty. |
| 3 | | 25¼ (Heard.) | | Breechblock closed with difficulty. |
| 3 | | Lost. | | Block cleaned and oiled after this round. |
| 3 | | 25¾ (Seen.) | | |
| 3 | | Lost. | | |
| | | | Mortar sighted by Lieut. O. M. Lissak, O. D. Fall of projectile observed by Lieut. W. W. Gibson, O. D. Stop-watch held by Capt. C. Shaler, O. D.<br>Firing conducted by Lieut. O. M. Lissak, O. D., assistant proof officer. | |

TARGET.

| No. of round. | Range. | Lateral deviation from plane of fire, right. | From center of impact, longitudinal. | | From center of impact, lateral. | |
|---|---|---|---|---|---|---|
| | | | + | — | Right. | Left. |
| | *Yards.* | *Yards.* | *Yds.* | *Yds.* | *Yds.* | *Yds.* |
| 436 | 3,301 | 90 | 19.6 | | | 4.8 |
| 437 | 3,257 | 91 | | 24.4 | | 3.8 |
| 438 | 3,363 | 100 | 81.6 | | 5.2 | |
| 439 | 3,253 | 98 | | 28.4 | 3.2 | |
| 440 | 3,140 | 94 | | 141.4 | | 0.8 |
| 441 | 3,413 | 95 | 131.6 | | 0.2 | |
| 442 | 3,307 | 90 | 25.6 | | | 4.8 |
| 443 | 3,258 | 89 | | 23.4 | | 5.8 |
| 444 | 3,224 | 101 | | 57.4 | 6.2 | |
| 445 | 3,298 | 100 | 16.6 | | 5.2 | |
| | 32,814 | 948 | 275.0 | 275.0 | 20.0 | 20.0 |

| | *Yards.* |
|---|---|
| Mean range | 3,281.4 |
| Mean deviation from plane of fire | 94.8 |
| Mean longitudinal deviation from center of impact | 55 |
| Mean lateral deviation from center of impact | 4 |

32,814+10=3,281.4 948+10=94.8 550+10=55.0 40+10=4.0

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1,*

[Object of firing, to test

| Date. | | No. of fire. | Powder. | | Projectile. | | Elevation. | Recoil. | Wind, strength and direction |
|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1891. | | | | *Pounds.* | | *Lbs. Oz.* | ° ′ | *Feet.* | |
| Feb. 12 | A. M...... | 446 | Du Pont's I. K. H. Lot 1. Density, 1.725. Granulation, 2,050. | 1 | Shell (banded), experimental. Lot 249. | 19 2<br>14 sand.<br>20 0 | 0 00 | ........ | From right and front, 9 miles an hour |
| | | 447 | | 1 | | 19 6<br>10 sand.<br>20 0 | 0 00 | ........ | |
| | | 448 | | 1 | | 19 9<br>7 sand.<br>20 0 | 0 00 | ........ | |
| | | 449 | | 1 | | 19 4<br>12 sand.<br>20 0 | 0 00 | ........ | |
| | | 450 | | 1 | | 19 4<br>12 sand.<br>20 0 | 0 00 | ........ | |
| | | 451 | | 1 | | 19 9<br>7 sand.<br>20 0 | 0 00 | ........ | |
| | | 452 | | 1 | | 19 1<br>15 sand.<br>20 0 | 0 00 | ........ | |
| | | 453 | | 1 | | 19 5<br>11 sand.<br>20 0 | 0 00 | ........ | |
| | | 454 | | 1 | | 19 5<br>11 sand.<br>20 0 | 0 00 | ........ | |
| | | 455 | | 1 | | 19 3<br>13 sand.<br>20 0 | 0 00 | ........ | |
| | | 456 | | 1 | | 19 5<br>11 sand.<br>20 0 | 0 00 | 6 | |
| | | 457 | | 1 | | *20 0 | 0 00 | 8 | |
| | | 458 | | 1 | | 19 1<br>15 sand.<br>20 0 | 0 00 | 8 | |
| | | 459 | | 1 | | 19 3<br>13 sand.<br>20 0 | 0 00 | 8 | |
| | | 460 | | 1 | | 19 1 sand.<br>15<br>20 0 | 0 00 | 8 | |

*Including sand.

*Watervliet Arsenal, at Sandy Hook, N. J., February 12, 1891.*

accuracy of mortar.]

| | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|
| Mortar mounted on new experimental steel carriage made at Watervliet Arsenal. Cannon friction primers (experimental), with spiral serrated wire, March, 1890. | |
| New vent shield fitted to mortar before this firing.<br>Recoil restrained by 2½-inch rope, arranged as in previous firing.<br>Fired into field butt.<br>Mortar carriage standing on platform of 3-inch spruce plank, 15 feet long, and inclined upward to the rear at an angle of 11 degrees.<br>Powder loose in chamber. | |
| | Mortar turned over on right side.<br>Rope allowed recoil of 6 feet. |
| | Rope allowed recoil of 8 feet. |
| | Mortar turned over on left side. |

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1, Watervli*

[Object of firing, to test

| Date. | | No. of fire. | Powder. | | Projectile. | | Elevation. | Recoil. | Wind strength and direction. |
|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1891. | | | | *Pounds.* | | *Lbs. Oz.* | ° ' | *Feet.* | |
| Feb. 12 | A. M...... | 461 | Du Pont's I. K. H. Lot 1. Density, 1.725. Granulation, 2,050. | 1 | Shell (banded), experimental. Lot 249. | 19 6<br>10 sand.<br>20 0 | 0 00 | 8 | From right and front, 9 miles an hour. |
| | | 462 | | 1 | | 19 3<br>13 sand.<br>20 0 | 0 00 | 8 | |
| | | 463 | | 1 | | 19 5<br>11 sand.<br>20 0 | 0 00 | 8 | |
| | | 464 | | 1 | | 19 1<br>15 sand.<br>20 0 | 0 00 | 9 | |
| | | 465 | | 1 | | 19 2<br>14 sand.<br>20 0 | 0 00 | 9 | |
| | | 466 | | 1 | | 19 5<br>11 sand.<br>20 0 | 0 00 | 9 | |
| | | 467 | | 1 | | 19 4<br>12 sand.<br>20 0 | 0 00 | 9 | |
| | | 468 | | 1 | | 19 2<br>14 sand.<br>20 0 | 0 00 | 9 | |
| Feb. 12 | P. M...... | 469 | Du Pont's I. K. H. Lot 23. Density, 1.725. Granulation, 2,595. | 1 | | 19 1<br>15 sand.<br>20 0 | 0 00 | 9 | |
| | | 470 | | 1 | | 19 5<br>11 sand.<br>20 0 | 0 00 | 9 | |
| | | 471 | | 1 | | 19 4<br>12 sand.<br>20 0 | 0 00 | 9 | |
| | | 472 | | 1 | | 19 2<br>14 sand.<br>20 0 | 0 00 | 9 | |
| | | 473 | | 1 | | 19 2<br>14 sand.<br>20 0 | 0 00 | 9 | |
| | | 474 | | 1 | | 19 3<br>13 sand.<br>20 0 | 0 00 | 9 | |
| | | 475 | | 1 | | 19 3<br>13 sand.<br>20 0 | 0 00 | 9 | |

*Arsenal, at Sandy Hook, N. J., February 12, 1891*—Continued.

accuracy of mortar.]

| | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|
| **Mortar mounted on new experimental steel carriage made at Watervliet Arsenal. Cannon friction primers (experimental), with spiral serrated wire, March, 1890.** | |
| | **Rope allowed recoil of 9 feet.** |
| **Powder loose in chamber. Fired into field butt...........** | **Mortar turned over on right side.** |
| | **Mortar turned over on right side.** |
| | **Mortar turned over on right side.** |

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1, Waterv*

[Object of firing

| Date. | No. of fire. | Powder. | | Projectile. | | Elevation. | Fuse marked. | Pressure per square inch of bore. |
|---|---|---|---|---|---|---|---|---|
| | | Kind. | Weight. | Kind. | Weight. | | | |
| 1891. | | | *Ounces.* | | *Lbs. Oz.* | ° ′ | | *Pounds* |
| Feb. 17 | 539 | Du Pont's I. K. H. Lot 16. Density, 1.725. Granulation, 2,524. | 8 | Shell (banded), experimental. Lot 249. Altered to receive Merriam fuses. | 19 0 including sand.<br>1 0 fuse.<br>20 0 | 15 00 | 4 | No. 4, 7.[illegible] |
| | 540 | | 6 | | 18 7<br>9 sand.<br>1 0 fuse.<br>20 9 | 15 00 | 3 | No. 5, 4.[illegible] |
| | 541 | | 5 | | 18 8<br>8 sand.<br>1 0 fuse.<br>20 0 | 15 00 | 1 | No. 4, 4.[illegible] |
| | 542 | | 4 | | 18 4<br>12 sand.<br>1 0 fuse.<br>20 0 | 15 00 | 2 | No. 5, 3.[illegible] |
| | 543 | | 5 | | 18 5<br>11 sand.<br>1 0 fuse.<br>20 0 | 15 00 | 2 | No. 4, 4.[illegible] |
| | 544 | | 5 | | 18 6<br>10 sand.<br>1 0 fuse.<br>20 0 | 15 00 | 6 | No. 5, 3.5[illegible] |

*Arsenal, at Sandy Hook, N. J., February 17, 1891*—Continued.

test Merriam fuses.]

| Recoil. | Wind, strength and direction. | | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|---|---|
| | | Mortar mounted on new experimental steel carriage made at Watervliet Arsenal. Cannon friction primers (experimental), model of 1887, September, 1890. | |
| *Ft. In.*<br>5 0 | From right, 10 miles an hour. | Fired down the beach.<br>Uncompressed copper cylinders and tables of 1890.<br>Recoil restrained by 2½-inch rope, arranged as in previous firing. | Two primers exploded, but failed to ignite cartridge; fuse exploded. |
| 5 0 | | | Fuse exploded. |
| 4 6 | | | Fuse exploded. |
| 2 0 | | | Fuse did not explode. |
| 2 0 | | | Fuse, same as used in previous round, did not explode. |
| 5 0 | | | Fuse did not explode. |
| | | Pressures taken by Lieut. C. B. Wheeler, O. D. Firing conducted by Lieut. O. M. Lissak, O. D., assistant proof officer. | |

*Record of firing with 3.6-inch B. L. field mortar (steel), N*

[Object of firing to

| Date. | | No. of fire. | Powder. Kind. | Powder. Weight. | Projectile. Kind. | Projectile. Weight. | Elevation. | Recoil. | Wind, strength, and direction. |
|---|---|---|---|---|---|---|---|---|---|
| 1891. | | | | *Pounds.* | | *Lbs. Oz.* | ° ′ | *Feet.* | |
| Feb. 18 | A.M........ | 545 | Du Pont's I. K. H. Lot 6. Density, 1.725. Granulation, 2,809. | 1 | Shell (banded), experimental. Lot 249. | 19 1<br>15 sand.<br>20 0 | 0 00 | 7 | From right and rear 20 miles an hour |
| | | 546 | | 1 | | 19 2<br>14 sand.<br>20 0 | 0 00 | 7 | |
| | | 547 | | 1 | | 19 6<br>10 sand.<br>20 0 | 0 00 | 7 | |
| | | 548 | | 1 | | 19 3<br>13 sand.<br>20 0 | 0 00 | 7 | |
| | | 549 | | 1 | | 19 2<br>14 sand.<br>20 0 | 0 00 | 7 | |
| | | 550 | | 1 | | 19 1<br>15 sand.<br>20 0 | 0 00 | 7 | |
| | | 551 | | 1 | | 19 2<br>14 sand.<br>20 0 | 0 00 | 7 | |
| | | 552 | | 1 | | 19 1<br>15 sand.<br>20 0 | 0 00 | 7 | |
| | | 553 | | 1 | | 19 4<br>12 sand.<br>20 0 | 0 00 | 7 | |
| | | 554 | | 1 | | 19 4<br>12 sand.<br>20 0 | 0 00 | 7 | |

*Watervliet Arsenal, at Sandy Hook, N. J., February 18, 1891.*

mortar for rapidity and endurance.]

| | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|
| Mortar mounted on new experimental steel carriage made at Watervliet Arsenal. Cannon friction primers, model 1887. | |
| Mortar carriage standing on platform of 3-inch spruce plank, 15 feet long, and inclined upward to the rear at an angle of 11 degrees.<br>Recoil restrained by 2¼-inch rope, arranged as in previous firing. Rope allowed recoil of 7 feet.<br>Fired into field butt, No. 2.<br>Powder loose in chamber. | Mortar turned over. |
| | Mortar turned over. |
| | Mortar turned over on right side. |
| | Mortar turned over on right side. |
| Time occupied in firing 10 rounds (545 to 554), 12 minutes and 45 seconds. | |

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1, Water*

[Object of firing

| Date. | | No. of fire. | Powder. | | Projectile. | | Elevation. | Recoil. | Wind strength and direction |
|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1891. | | | | *Pounds.* | | *Lbs. oz.* | ° ′ | *Feet.* | |
| Feb. 18 | A.M...... | 555 | Du Pont's I. K.-H. Lot 6. Density, 1.725. Granulation, 2,809. | 1 | Shell (banded), experimental. Lot 249. | 19 4<br>12 sand.<br>20 0 | 0 00 | 7 | From right and rear, 29 miles an hour. |
| | | 556 | | 1 | | 19 3<br>13 sand.<br>20 0 | 0 00 | 7 | |
| | | 557 | | 1 | | 19 2<br>14 sand.<br>20 0 | 0 00 | 7 | |
| | | 558 | | 1 | | 19 1<br>15 sand.<br>20 0 | 0 00 | 7 | |
| | | 559 | | 1 | | 19 1<br>15 sand.<br>20 0 | 0 00 | 7 | |
| | | 560 | | 1 | | 19 5<br>11 sand.<br>20 0 | 0 00 | 7 | |
| | | 561 | | 1 | | 19 5<br>11 sand.<br>20 0 | 0 00 | 7 | |
| | | 562 | | 1 | | 19 3<br>13 sand.<br>20 0 | 0 00 | 7 | |
| | | 563 | | 1 | | 19 2<br>14 sand.<br>20 0 | 0 00 | 7 | |
| | | 564 | | 1 | | 19 2<br>14 sand.<br>20 0 | 0 00 | 7 | |

*Arsenal, at Sandy Hook, N. J., February 18, 1891*—Continued.

special rapidity test.]

| | **Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data.** |
|---|---|
| **Cannon friction primers, model of 1887.** | |
| **Fired into field butt, No. 2. Powder loose in chamber.** | |
| **Time occupied in firing 10 rounds (555 to 564), 8 minutes and 30 seconds.** | |

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1, Watervliet*

**[Object of firing, to test mortar**

| Date. | | No. of fire. | Powder. | | Projectile. | | Elevation. | Recoil. | Wind, strength and direction |
|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1891. | | | | *Pounds.* | | *Lbs. Oz.* | ° ′ | *Feet.* | |
| Feb. 18 | A. M...... | 565 | Du Pont's I. K. H. Lot 6. Density, 1.725. Granulation, 2,809. | 1 | Shell (banded), experimental. Lot 249. | 19 4<br>12 sand.<br>20 0 | 0 00 | 7 | From right and rear, 29 miles an hour. |
| | | 566 | | 1 | | 19 2<br>14 sand.<br>20 0 | 0 00 | 7 | |
| | | 567 | | 1 | | 19 3<br>13 sand.<br>20 0 | 0 00 | 7 | |
| | | 568 | | 1 | | 19 4<br>12 sand.<br>20 0 | 0 00 | 7 | |
| | | 569 | Du Pont's I. K. H. Lot 7. Density, 1.725. Granulation 2,943. | 1 | | 19 2<br>14 sand.<br>20 0 | 0 00 | 7 | |
| | | 570 | | 1 | | 19 2<br>14 sand.<br>20 0 | 0 00 | 7 | |
| | | 571 | | 1 | | 19 5<br>11 sand.<br>20 0 | 0 00 | 7 | |
| | | 572 | | 1 | | 19 5<br>11 sand.<br>20 0 | 0 00 | 7 | |
| | | 573 | | 1 | | 19 3<br>13 sand.<br>20 0 | 0 00 | 7 | |
| | | 574 | | 1 | | 19 4<br>12 sand.<br>20 0 | 0 00 | 7 | |
| | | 575 | | 1 | | 19 4<br>12 sand.<br>20 0 | 0 00 | 7 | |
| | | 576 | | 1 | | 19 5<br>11 sand.<br>20 0 | 0 00 | 7 | |
| | | 577 | | 1 | | 19 3<br>13 sand.<br>20 0 | 0 00 | 7 | |
| | | 578 | | 1 | | 19 2<br>14 sand.<br>20 0 | 0 00 | 7 | |
| | | 579 | | 1 | | 19 3<br>13 sand.<br>20 0 | 0 00 | 7 | |
| | | 580 | | 1 | | 19 5<br>11 sand.<br>20 0 | 0 00 | 7 | |

*Arsenal, at Sandy Hook, N. J., February 18, 1891*—Continued.

for rapidity and endurance.]

| | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|
| Cannon friction primers, model of 1887. | |
| | Mortar turned over on left side. |
| Between rounds 564 and 565 there was a delay of 3 minutes and 10 seconds on account of repairs being made to platform.<br>Time occupied in firing 5 rounds (565 to 569), 5 minutes and 50 seconds.<br>Fired into field butt, No. 2.<br>Powder loose in chamber.<br>Time occupied in firing 5 rounds (570 to 574), 5 minutes and 50 seconds. | Mortar turned over on right side. |
| | Primer failed. |

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1, Waterrliet*

[Object of firing, to test mortar.

| Date. | | No. of fire. | Powder. Kind. | Powder. Weight. | Projectile. Kind. | Projectile. Weight. | Elevation. | Recoil. | Wind, strength and direction. |
|---|---|---|---|---|---|---|---|---|---|
| 1891. | | | | *Pounds.* | | *Lbs. Oz.* | ° ′ | *Feet.* | |
| Feb. 18 | A. M...... | 581 | Du Pont's I. K. H. Lot 7. Density, 1.725. Granulation, 2,943. | 1 | Shell (banded), experimental. Lot 249. | 19 2<br>14 sand.<br>20 0 | 0 00 | 7 | From right and rear, 29 miles an hour. |
| | | 582 | | 1 | | 19 2<br>14 sand.<br>20 0 | 0 00 | 7 | |
| | | 583 | | 1 | | 19 1<br>15 sand.<br>20 0 | 0 00 | 7 | |
| | | 584 | | 1 | | 19 1<br>15 sand.<br>20 0 | 0 00 | 7 | |

[Object of firin

| Date. | | No. of fire. | Powder. Kind. | Powder. Weight. | Projectile. Kind. | Projectile. Weight. | Elevation. | Recoil. | Wind, strength and direction. |
|---|---|---|---|---|---|---|---|---|---|
| Feb. 18 | A. M...... | 585 | Du Pont's I. K. H. Lot 7. Density, 1.725. Granulation, 2,943. | 1 | Shell (banded), experimental. Lot 249. | 19 2<br>14 sand<br>20 0 | 0 00 | 7 | From right and rear, 29 miles an hour. |
| | | 586 | | 1 | | 19 2<br>14 sand.<br>20 0 | 0 00 | 7 | |
| | | 587 | | 1 | | 19 3<br>13 sand.<br>20 0 | 0 00 | 7 | |
| | | 588 | | 1 | | 19 1<br>15 sand.<br>20 0 | 0 00 | 7 | |
| | | 589 | | 1 | | 19 3<br>13 sand.<br>20 0 | 0 00 | 7 | |
| | | 590 | | 1 | | 19 1<br>15 sand.<br>20 0 | 0 00 | 7 | |
| | | 591 | | 1 | | 19 2<br>14 sand.<br>20 0 | 0 00 | 7 | |
| | | 592 | | 1 | | 19 3<br>13 sand.<br>20 0 | 0 00 | 7 | |
| | | 593 | | 1 | | 19 3<br>13 sand.<br>20 0 | 0 00 | 7 | |
| | | 594 | | 1 | | 19 3<br>13 sand.<br>20 0 | 0 00 | 7 | |

*Arsenal, at Sandy Hook, N. J., February 18, 1891*—Continued.

for rapidity and endurance.]

| | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|
| Cannon friction primers, model of 1887. | Mortar turned over on right side. |
| Powder loose in chamber.<br>Fired into field butt, No. 2.<br>Time occupied in firing 10 rounds (575 to 584), 13 minutes and 30 seconds. | |
| | Mortar turned over. |

special rapidity test.]

| | |
|---|---|
| Cannon friction primers, model of 1887. | |
| Powder loose in chamber.<br>Gun detachment consisted of 1 noncommissioned officer and 2 men.<br>Fired into field butt, No. 2.<br>Time occupied in firing 10 rounds (585 to 594), 6 minutes and 50 seconds.<br>Total time occupied in firing 50 rounds, 56 minutes and 25 seconds, including delay of 3 minutes and 10 seconds. | |
| Firing conducted by Lieut. O. M. Lissak, O. D., assistant proof officer.<br>Mortar star gauged after round 594, February 18, 1891, by Lieut. O. M. Lissak, O. D. | |

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1.*

[Object of firing, to test

| Date. | | No. of fire. | Powder. | | Projectile. | | Including sand. | Elevation. | Recoil. | Wind, strength and direction. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Wgt. | Kind. | Wgt. | | | | |
| 1891. | | | | *Lbs.* | | *Lbs.* | *Lbs. Oz.* | ° ′ | *Feet.* | |
| Feb. 24 | A. M. | 595 | Lot 7. Density, 1.725. Granulation, 2,500. | 1 | Shell (banded), experimental. Lot 249. | 20 | 1 0 | 0 00 | ........ | From right and front, 9 miles an hour. |
| | | 596 | | 1 | | 20 | 14 | 0 00 | ........ | |
| | | 597 | | 1 | | 20 | 13 | 0 00 | 9 | |
| | | 598 | | 1 | | 20 | 14 | 0 00 | 9 | |
| | | 599 | Lot 12. Density, 1.725. Granulation, 2,510. | 1 | | 20 | 15 | 0 00 | 9 | |
| | | 600 | | 1 | | 20 | 12 | 0 00 | 9 | |
| | | 601 | | 1 | | 20 | 15 | 0 00 | 9 | |
| | | 602 | | 1 | | 20 | 14 | 0 00 | 9 | |
| | | 603 | Du Pont's I. K. H. Lot 9. Density, 1.725. Granulation, 2,532. | 1 | | 20 | 15 | 0 00 | 9 | |
| | | 604 | | 1 | | 20 | 14 | 0 00 | 9 | |
| | | 605 | | 1 | | 20 | 13 | 0 00 | 9 | |
| | | 606 | | 1 | | 20 | 14 | 0 00 | 9 | |
| | | 607 | | 1 | | 20 | 15 | 0 00 | 9 | |
| | | 608 | | 1 | | 20 | 15 | 0 00 | 9 | |
| | | 609 | | 1 | | 20 | 14 | 0 00 | 9 | |
| | | 610 | | 1 | | 20 | 14 | 0 00 | 9 | |
| | | 611 | | 1 | | 20 | 14 | 0 00 | 9 | |
| | | 612 | | 1 | | 20 | 12 | 0 00 | 9 | |
| | | 613 | | 1 | | 20 | 11 | 0 00 | 9 | |
| | | 614 | | 1 | | 20 | 11 | 0 00 | 9 | |
| | | 615 | | 1 | | 20 | 15 | 0 00 | 9 | |
| | | 616 | | 1 | | 20 | 14 | 0 00 | 9 | |
| | | 617 | | 1 | | 20 | 15 | 0 00 | 9 | |
| | | 618 | | 1 | | 20 | 13 | 0 00 | 9 | |
| | | 619 | | 1 | | 20 | 15 | 0 00 | 9 | |
| | | 620 | | 1 | | 20 | 15 | 0 00 | 9 | |
| | | 621 | | 1 | | 20 | 15 | 0 00 | 9 | |
| | | 622 | | 1 | | 20 | 16 | 0 00 | 9 | |
| | | 623 | | 1 | | 20 | 15 | 0 00 | 9 | |
| | | 624 | | 1 | | 20 | 14 | 0 00 | 9 | |
| | | 625 | | 1 | | 20 | 15 | 0 00 | 9 | |
| | | 626 | | 1 | | 20 | 10 | 0 00 | 9 | |
| | | 627 | | 1 | | 20 | 14 | 0 00 | 9 | |
| | | 628 | | 1 | | 20 | 11 | 0 00 | 9 | |
| | | 629 | | 1 | | 20 | 10 | 0 00 | 9 | |
| | | 630 | | 1 | | 20 | 15 | 0 00 | 9 | |
| | | 631 | | 1 | | 20 | 11 | 0 00 | 9 | |
| | | 632 | | 1 | | 20 | 14 | 0 00 | 9 | |
| | | 633 | | 1 | | 20 | 14 | 0 00 | 9 | |
| | | 634 | | 1 | | 20 | 14 | 0 00 | 9 | |
| | | 635 | Du Pont's I. K. H. Lot 10. Density, 1.725. Granulation, 2,586. | 1 | | 20 | 11 | 0 00 | 9 | |
| | | 636 | | 1 | | 20 | 12 | 0 00 | 9 | |
| | | 637 | | 1 | | 20 | 14 | 0 00 | 9 | |
| | | 638 | | 1 | | 20 | 11 | 0 00 | 9 | |
| | | 639 | | 1 | | 20 | 15 | 0 00 | 9 | |
| | | 640 | | 1 | | 20 | 12 | 0 00 | 9 | |
| | | 641 | | 1 | | 20 | 13 | 0 00 | 9 | |
| | | 642 | | 1 | | 20 | 13 | 0 00 | 9 | |
| | | 643 | | 1 | | 20 | 12 | 0 00 | 9 | |
| | | 644 | | 1 | | 20 | 15 | 0 00 | 9 | |
| | | 645 | | 1 | | 20 | 13 | 0 00 | 9 | |
| | | 646 | | 1 | | 20 | 14 | 0 00 | 9 | |
| | | 647 | | 1 | | 20 | 13 | 0 00 | 9 | |
| | | 648 | | 1 | | 20 | 13 | 0 00 | 9 | |
| | | 649 | | 1 | | 20 | 14 | 0 00 | 9 | |
| | | 650 | | 1 | | 20 | 14 | 0 00 | 9 | |
| | | 651 | | 1 | | 20 | 14 | 0 00 | 9 | |
| | | 652 | | 1 | | 20 | 13 | 0 00 | 9 | |
| | | 653 | | 1 | | 20 | 14 | 0 00 | 9 | |
| | | 654 | | 1 | | 20 | 13 | 0 00 | 9 | |
| | | 655 | | 1 | | 20 | 1 1 | 0 00 | 9 | |
| | | 656 | | 1 | | 20 | 15 | 0 00 | 9 | |
| | | 657 | | 1 | | 20 | 13 | 0 00 | 9 | |
| | | 658 | | 1 | | 20 | 14 | 0 00 | 9 | |
| | | 659 | | 1 | | 20 | 15 | 0 00 | 9 | |
| | | 660 | | 1 | | 20 | 14 | 0 00 | 9 | |
| | | 661 | | 1 | | 20 | 13 | 0 00 | 9 | |
| | | 662 | | 1 | | 20 | 15 | 0 00 | 9 | |
| | | 663 | | 1 | | 20 | 15 | 0 00 | 9 | |
| | | 664 | | 1 | | 20 | 13 | 0 00 | 9 | |
| | | 665 | | 1 | | 20 | 15 | 0 00 | 9 | |

*Watervliet Arsenal, at Sandy Hook, N. J., February 24, 1891.*

**mortar for endurance.]**

| | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|
| Mortar mounted on new experimental steel carriage made at Watervliet Arsenal. Cannon friction primers, model of 1887. | |
| | Mortar turned over on left side.<br>Mortar recoiled off platform. |
| Mortar carriage standing on platform of 8-inch spruce plank, 15 feet long, and inclined upward to the rear at an angle of 11 degrees.<br>Fired into field butt, section 2.<br>Recoil restrained by 2½-inch rope, arranged as in previous firing. Rope allowed recoil of 9 feet.<br>Powder loose in chamber. | |
| | Breech and block wiped and oiled. |
| | Breech and block wiped and oiled. |

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1, Watervl*

[Object of firing, to test

| Date. | | No. of fire. | Powder. | | Projectile. | | Including sand. | | Elevation. | | Recoil. | Wind strength and direction. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Wgt. | Kind. | Wgt. | | | | | | |
| 1891. | | | | Lbs. | | Lbs. | Lbs. | Oz. | ° | ′ | Feet. | |
| Feb. 24 | A. M ....... | 666 | DuPont's I. K. H. Lot 8. Density, 1.725. Granulation, 2,630. | 1 | Shell (banded), experimental. Lot 249. | 20 | | 14 | 0 | 00 | 9 | From right and front, 0 miles an hour. |
| | | 667 | | 1 | | 20 | | 11 | 0 | 00 | 9 | |
| | | 668 | | 1 | | 20 | | 11 | 0 | 00 | 9 | |
| | | 669 | | 1 | | 20 | | 14 | 0 | 00 | 9 | |
| | | 670 | | 1 | | 20 | | 13 | 0 | 00 | 9 | |
| | | 671 | | 1 | | 20 | | 14 | 0 | 00 | 9 | |
| | | 672 | | 1 | | 20 | | 16 | 0 | 00 | 9 | |
| | | 673 | | 1 | | 20 | | 13 | 0 | 00 | 9 | |
| | | 674 | | 1 | | 20 | | 15 | 0 | 00 | 9 | |
| | | 675 | | 1 | | 20 | | 15 | 0 | 00 | 9 | |
| | | 676 | | 1 | | 20 | 1 | 1 | 0 | 00 | 9 | |
| | | 677 | | 1 | | 20 | | 14 | 0 | 00 | 9 | |
| | | 678 | | 1 | | 20 | | 13 | 0 | 00 | 9 | |
| | | 679 | | 1 | | 20 | | 14 | 0 | 00 | 9 | |
| | | 680 | | 1 | | 20 | | 15 | 0 | 00 | 9 | |
| | | 681 | | 1 | | 20 | | 11 | 0 | 00 | 9 | |
| | | 682 | | 1 | | 20 | | 14 | 0 | 00 | 9 | |
| | | 683 | DuPont's I. K. H. Lot 11. Density, 1.725. Granulation, 2,459. | 1 | | 20 | | 15 | 0 | 00 | 9 | |
| | | 684 | | 1 | | 20 | | 15 | 0 | 00 | 9 | |
| | | 685 | | 1 | | 20 | | 14 | 0 | 00 | 9 | |
| | | 686 | | 1 | | 20 | | 14 | 0 | 00 | 9 | |
| | | 687 | | 1 | | 20 | | 15 | 0 | 00 | 9 | |
| | | 688 | | 1 | | 20 | | 13 | 0 | 00 | 9 | |
| | | 689 | | 1 | | 20 | 1 | 0 | 0 | 00 | 9 | |
| | | 690 | | 1 | | 20 | | 15 | 0 | 00 | 9 | |
| | | 691 | | 1 | | 20 | | 14 | 0 | 00 | 9 | |
| | | 692 | | 1 | | 20 | | 13 | 0 | 00 | 9 | |
| | | 693 | | 1 | | 20 | | 13 | 0 | 00 | 9 | |
| | | 694 | | 1 | | 20 | | 12 | 0 | 00 | 9 | |
| Feb. 24 | P. M ....... | 695 | | 1 | | 20 | | 14 | 0 | 00 | 10 | |
| | | 696 | | 1 | | 20 | | 14 | 0 | 00 | 10 | |
| | | 697 | | 1 | | 20 | | 14 | 0 | 00 | 10 | |
| | | 698 | | 1 | | 20 | 1 | 0 | 0 | 00 | 10 | |
| | | 699 | | 1 | | 20 | | 15 | 0 | 00 | 10 | |
| | | 700 | | 1 | | 20 | | 14 | 0 | 00 | 10 | |
| | | 701 | | 1 | | 20 | | 14 | 0 | 00 | 10 | |
| | | 702 | | 1 | | 20 | | 11 | 0 | 00 | 10 | |
| | | 703 | | 1 | | 20 | | 11 | 0 | 00 | 10 | |
| | | 704 | | 1 | | 20 | | 13 | 0 | 00 | 10 | |
| | | 705 | | 1 | | 20 | | 12 | 0 | 00 | 10 | |
| | | 706 | | 1 | | 20 | | 12 | 0 | 00 | 10 | |
| | | 707 | | 1 | | 20 | | 14 | 0 | 00 | 10 | |
| | | 708 | | 1 | | 20 | | 14 | 0 | 00 | 10 | |
| | | 709 | | 1 | | 20 | | 15 | 0 | 00 | 10 | |
| | | 710 | | 1 | | 20 | | 14 | 0 | 00 | 10 | |
| | | 711 | | 1 | | 20 | | 14 | 0 | 00 | 10 | |
| | | 712 | | 1 | | 20 | | 13 | 0 | 00 | 10 | |
| | | 713 | | 1 | | 20 | | 14 | 0 | 00 | 10 | |
| | | 714 | | 1 | | 20 | | 14 | 0 | 00 | 10 | |

A. MORDECAI,
*Colonel Ordnance Department, U. S. A., President of the Board.*

*Arsenal, at Sandy Hook, N. J., February 24, 1891*—Continued.

mortar for endurance.]

| | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|
| Mortar mounted on new experimental steel carriage made at Watervliet Arsenal. Cannon friction primers, model of 1887. | |
| | Vent shield broken off. |
| | Rope allowed recoil of 9 feet. |
| Recoil restrained by 2½-inch rope, arranged as in previous firing.<br>Fired into field butt, section 2.<br>Powder loose in chamber.<br>Elevation of piece increased by shock of discharge at each fire. | |
| | Rope allowed recoil of 10 feet. Five hundredth round with full charge. |
| | Mortar fell forward on face. |
| | Mortar fell forward on face. |
| | Mortar turned over on right side. |
| Condition of mortar after completion of test: Front sight bent and partly unscrewed. Carrying bolts in trunnions partly unscrewed. One lever handle bent. Arc of elevating apparatus worn smooth by clamps. Vent shield broken.<br>Firing conducted by Lieut. O. M. Lissak, O. D., assistant proof officer. Mortar star gauged after round 694, February 24, 1891, by Lieut. O. M. Lissak, O. D. | |

ORMOND M. LISSAK,
*Lieutenant Ordnance Department, Recorder.*

*Star-gauging of 3.6-inch B. L. field mortar, No. 1, Watervliet Arsenal, at Sandy Hook, N. J., August 12, 1890.*

| Inches from breech. | After 90 rounds, chamber. | Inches from muzzle. | After 90 rounds, lands. | Inches from muzzle. | After 90 rounds, lands. | Inches from muzzle. | After 90 rounds, lands. | Inches from muzzle. | After 90 rounds, lands. |
|---|---|---|---|---|---|---|---|---|---|
| 6¼ | 3.809 | ½ | 3.607 | 4 | 3.606 | 7½ | 3.607 | 11 | 3.623 |
| 6¾ | 3.809 | 1 | 3.607 | 4½ | 3.606 | 8 | 3.608 | 11½ | 3.626 |
| 7¼ | 3.809 | 1½ | 3.607 | 5 | 3.606 | 8½ | 3.610 | 12 | 3.628 |
| 7¾ | 3.809 | 2 | 3.6065 | 5½ | 3.606 | 9 | 3.6115 | 12½ | 3.632 |
| 8¼ | 3.809 | 2½ | 3.606 | 6 | 3.606 | 9½ | 3.6155 | 13 | 3.634 |
| 8¾ | 3.809 | 3 | 3.606 | 6½ | 3.6065 | 10 | 3.618 | 13½ | 3.637 |
| 9¼ | 3.809 | 3½ | 3.606 | 7 | 3.6065 | 10½ | 3.6205 | 14 | 3.638 |

*Star-gauging of 3.6-inch B. L. field mortar (steel), No. 1, Watervliet Arsenal, at Sandy Hook, N. J., November 26, 1890.*

| Inches from muzzle. | After round 222, lands. | Inches from muzzle. | After round 222, lands. | Inches from muzzle. | After round 222, lands. | Inches from muzzle. | After round 222, lands. | Inches from breech. | After round 222, chamber vertical. |
|---|---|---|---|---|---|---|---|---|---|
| ½ | 3.609 | 4 | 3.6075 | 7½ | 3.6110 | 11 | 3.6250 | 6¼ | 3.809 |
| 1 | 3.6085 | 4½ | 3.608 | 8 | 3.6115 | 11½ | 3.6275 | 6¾ | 3.809 |
| 1½ | 3.608 | 5 | 3.6085 | 8½ | 3.6125 | 12 | 3.6300 | 7¼ | 3.809 |
| 2 | 3.608 | 5½ | 3.609 | 9 | 3.6150 | 12½ | 3.6325 | 7¾ | 3.809 |
| 2½ | 3.608 | 6 | 3.609 | 9½ | 3.6175 | 13 | 3.6350 | 8¼ | 3.809 |
| 3 | 3.6075 | 6½ | 3.6100 | 10 | 3.6195 | 13½ | 3.6380 | 8¾ | 3.809 |
| 3½ | 3.6075 | 7 | 3.6105 | 10½ | 3.6225 | 14 | 3.6390 | 9¼ | 3.8095 |

*Star-gauging of 3.6-inch B. L. field mortar (steel), No. 1, Watervliet Arsenal, at Sandy Hook, N. J., January 30, 1891.*

| Inches from muzzle. | After round 378, lands. | Inches from muzzle. | After round 378, lands. | Inches from muzzle. | After round 378, lands. | Inches from breech. | After round 378, chamber. |
|---|---|---|---|---|---|---|---|
| ½ | 3.610 | 5 | 3.6085 | 9½ | 3.617 | 6¼ | 3.809 |
| 1 | 3.609 | 5½ | 3.609 | 10 | 3.619 | 7¾ | 3.809 |
| 1½ | 3.6085 | 6 | 3.6095 | 10½ | 3.621 | 9¼ | 3.810 |
| 2 | 3.608 | 6½ | 3.610 | 11 | 3.624 | | |
| 2½ | 3.608 | 7 | 3.610 | 11½ | 3.627 | | |
| 3 | 3.608 | 7½ | 3.611 | 12 | 3.629 | | |
| 3½ | 3.608 | 8 | 3.612 | 12½ | 3.632 | | |
| 4 | 3.6085 | 8½ | 3.613 | 13 | 3.635 | | |
| 4½ | 3.6085 | 9 | 3.614 | 13½ | 3.638 | | |

*Star-gauging of 3.6-inch B. L. field mortar (steel), No. 1, Watervliet Arsenal, at Sandy Hook, N. J., February 13, 1891.*

| Inches from muzzle. | After round 488, lands. | Inches from muzzle. | After round 488, lands. | Inches from muzzle. | After round 488, lands. | Inches from muzzle. | After round 488, chamber. |
|---|---|---|---|---|---|---|---|
| ½ | 3.611 | 5 | 3.610 | 9½ | 3.6185 | 6¼ | 3.809 |
| 1 | 3.610 | 5½ | 3.6105 | 10 | 3.621 | 7¾ | 3.809 |
| 1½ | 3.610 | 6 | 3.611 | 10½ | 3.624 | 9¼ | 3.810 |
| 2 | 3.610 | 6½ | 3.611 | 11 | 3.627 | | |
| 2½ | 3.609 | 7 | 3.612 | 11½ | 3.629 | | |
| 3 | 3.610 | 7½ | 3.612 | 12 | 3.6305 | | |
| 3½ | 3.609 | 8 | 3.613 | 12½ | 3.633 | | |
| 4 | 3.610 | 8½ | 3.614 | 13 | 3.636 | | |
| 4½ | 3.610 | 9 | 3.617 | 13½ | 3.639 | | |

*Star-gauging of 3.6-inch B. L. field mortar (steel), No. 1, Watervliet Arsenal, at Sandy Hook, N. J., February 18, 1891.*

| Inches from muzzle. | After round 594, lands. | Inches from muzzle. | After round 594, lands. | Inches from muzzle. | After round 594, lands. | Inches from breech. | After round 594, chamber. |
|---|---|---|---|---|---|---|---|
| ½ | 3.613 | 5 | 3.612 | 9½ | 3.619 | 6¼ | 3.81 |
| 1 | 3.612 | 5½ | 3.6115 | 10 | 3.621 | 7¾ | 3.81 |
| 1½ | 3.6115 | 6 | 3.6125 | 10½ | 3.624 | 9¼ | 3.8105 |
| 2 | 3.6115 | 6½ | 3.613 | 11 | 3.627 | | |
| 2½ | 3.611 | 7 | 3.613 | 11½ | 3.6285 | | |
| 3 | 3.611 | 7½ | 3.614 | 12 | 3.631 | | |
| 3½ | 3.611 | 8 | 3.614 | 12½ | 3.633 | | |
| 4 | 3.611 | 8½ | 3.6155 | 13 | 3.637 | | |
| 4½ | 3.611 | 9 | 3.617 | 13½ | 3.639 | | |

*Star-gauging of 3.6-inch B. L. mortar (steel), No. 1, Watervliet Arsenal, at Sandy Hook, N. J., February 24, 1891.*

| Inches from muzzle. | After round 694, lands. | Inches from muzzle. | After round 694, lands. | Inches from muzzle. | After round 694, lands. | Inches from breech. | After round 694, chamber. |
|---|---|---|---|---|---|---|---|
| ½ | 3.616 | 5 | 3.6145 | 9½ | 3.623 | 6¼ | 3.811 |
| 1 | 3.615 | 5½ | 3.615 | 10 | 3.624 | 7¾ | 3.811 |
| 1½ | 3.615 | 6 | 3.6155 | 10½ | 3.627 | 9¼ | 3.812 |
| 2 | 3.615 | 6½ | 3.616 | 11 | 3.6295 | | |
| 2½ | 3.615 | 7 | 3.616 | 11½ | 3.6315 | | |
| 3 | 3.6145 | 7½ | 3.6165 | 12 | 3.6335 | | |
| 3½ | 3.6145 | 8 | 3.617 | 12½ | 3.636 | | |
| 4 | 3.6145 | 8½ | 3.618 | 13 | 3.6385 | | |
| 4½ | 3.6145 | 9 | 3.620 | 13½ | 3.6405 | | |

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1, Watervliet*

[Object of firing, to test morta

| Date. | | No. of fire. | Powder. Kind. | Powder. Weight. | Projectile. Kind. | Projectile. Weight. | Elevation. | Recoil. | Wind strength and di-rection |
|---|---|---|---|---|---|---|---|---|---|
| 1891. | | | | *Pounds.* | | *Lbs. Oz.* | ° ′ | *Feet.* | |
| Feb. 18 | A. M...... | 565 | Du Pont's I. K. H. Lot 6. Density, 1.725. Granulation, 2,809. | 1 | Shell (banded), experimental. Lot 249. | 19 4<br>12 sand.<br>20 0 | 0 00 | 7 | From right and rear, 29 miles an hour. |
| | | 566 | | 1 | | 19 2<br>14 sand.<br>20 0 | 0 00 | 7 | |
| | | 567 | | 1 | | 19 3<br>13 sand.<br>20 0 | 0 00 | 7 | |
| | | 568 | | 1 | | 19 4<br>12 sand.<br>20 0 | 0 00 | 7 | |
| | | 569 | Du Pont's I. K. H. Lot 7. Density, 1.725. Granulation. 2,943. | 1 | | 19 2<br>14 sand.<br>20 0 | 0 00 | 7 | |
| | | 570 | | 1 | | 19 2<br>14 sand.<br>20 0 | 0 00 | 7 | |
| | | 571 | | 1 | | 19 5<br>11 sand.<br>20 0 | 0 00 | 7 | |
| | | 572 | | 1 | | 19 5<br>11 sand.<br>20 0 | 0 00 | 7 | |
| | | 573 | | 1 | | 19 3<br>13 sand.<br>20 0 | 0 00 | 7 | |
| | | 574 | | 1 | | 19 4<br>12 sand.<br>20 0 | 0 00 | 7 | |
| | | 575 | | 1 | | 19 4<br>12 sand.<br>20 0 | 0 00 | 7 | |
| | | 576 | | 1 | | 19 5<br>11 sand.<br>20 0 | 0 00 | 7 | |
| | | 577 | | 1 | | 19 3<br>13 sand.<br>20 0 | 0 00 | 7 | |
| | | 578 | | 1 | | 19 2<br>14 sand.<br>20 0 | 0 00 | 7 | |
| | | 579 | | 1 | | 19 3<br>13 sand.<br>20 0 | 0 00 | 7 | |
| | | 580 | | 1 | | 19 5<br>11 sand.<br>20 0 | 0 00 | 7 | |

Arsenal, at Sandy Hook, N. J., February 18, 1891—Continued.

or rapidity and endurance.]

| | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|
| Cannon friction primers, model of 1887. | |
| | Mortar turned over on left side. |
| Between rounds 564 and 565 there was a delay of 3 minutes and 10 seconds on account of repairs being made to platform. | Mortar turned over on right side. |
| Time occupied in firing 5 rounds (565 to 569), 5 minutes and 50 seconds. | |
| Fired into field butt, No. 2. | |
| Powder loose in chamber. | |
| Time occupied in firing 5 rounds (570 to 574), 5 minutes and 50 seconds. | |
| | Primer failed. |

| Date. | | No. of fire. | Powder. | | Projectile. | | Elevation. | Recoil. | Wind, strength and direction. |
|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1891. | | | | *Pounds.* | | *Lbs. oz.* | ° ′ | *Feet.* | |
| Feb. 18 | A. M...... | 555 | Du Pont's I. K. H. Lot 6. Density, 1.725. Granulation, 2,809. | 1 | Shell (banded), experimental. Lot 249. | 19 4<br>12 sand.<br>20 0 | 0 00 | 7 | From right and rear, 29 miles an hour. |
| | | 556 | | 1 | | 19 3<br>13 sand.<br>20 0 | 0 00 | 7 | |
| | | 557 | | 1 | | 19 2<br>14 sand.<br>20 0 | 0 00 | 7 | |
| | | 558 | | 1 | | 19 1<br>15 sand.<br>20 0 | 0 00 | 7 | |
| | | 559 | | 1 | | 19 1<br>15 sand.<br>20 0 | 0 00 | 7 | |
| | | 560 | | 1 | | 19 5<br>11 sand.<br>20 0 | 0 00 | 7 | |
| | | 561 | | 1 | | 19 5<br>11 sand.<br>20 0 | 0 00 | 7 | |
| | | 562 | | 1 | | 19 3<br>13 sand.<br>20 0 | 0 00 | 7 | |
| | | 563 | | 1 | | 19 2<br>14 sand.<br>20 0 | 0 00 | 7 | |
| | | 564 | | 1 | | 19 2<br>14 sand.<br>20 0 | 0 00 | 7 | |

*Arsenal, at Sandy Hook, N. J., February 18, 1891*—Continued.

**for rapidity and endurance.]**

| | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|
| Cannon friction primers, model of 1887.<br>Powder loose in chamber.<br>Fired into field butt, No. 2.<br>Time occupied in firing 10 rounds (575 to 584), 13 minutes and 30 seconds. | Mortar turned over on right side. |
| | Mortar turned over. |

**special rapidity test.]**

| | |
|---|---|
| Cannon friction primers, model of 1887.<br>Powder loose in chamber.<br>Gun detachment consisted of 1 noncommissioned officer and 2 men.<br>Fired into field butt, No. 2.<br>Time occupied in firing 10 rounds (585 to 594), 6 minutes and 50 seconds.<br>Total time occupied in firing 50 rounds, 56 minutes and 25 seconds, including delay of 3 minutes and 10 seconds.<br>Firing conducted by Lieut. O. M. Lissak, O. D., assistant proof officer.<br>Mortar star gauged after round 594, February 18, 1891, by Lieut. O. M. Lissak, O. D. | |

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1, Watervlie*

[Object of firing, to test morta

| Date. | | No. of fire. | Powder. | | Projectile. | | Eleva-tion. | Recoil. | Wind, strength and di-rection. |
|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1891. | | | | *Pounds.* | | *Lbs. Oz.* | ° ′ | *Feet.* | |
| Feb. 18 | A. M...... | 565 | Du Pont's I. K. H. Lot 6. Density, 1.725. Granulation, 2,809. | 1 | Shell (banded), experimental. Lot 249. | 19 4<br>12 sand.<br>20 0 | 0 00 | 7 | From right and rear, 29 miles an hour. |
| | | 566 | | 1 | | 19 2<br>14 sand.<br>20 0 | 0 00 | 7 | |
| | | 567 | | 1 | | 19 3<br>13 sand.<br>20 0 | 0 00 | 7 | |
| | | 568 | | 1 | | 19 4<br>12 sand.<br>20 0 | 0 00 | 7 | |
| | | 569 | Du Pont's I. K. H. Lot 7. Density, 1.725. Granulation 2,943. | 1 | | 19 2<br>14 sand.<br>20 0 | 0 00 | 7 | |
| | | 570 | | 1 | | 19 2<br>14 sand.<br>20 0 | 0 00 | 7 | |
| | | 571 | | 1 | | 19 5<br>11 sand.<br>20 0 | 0 00 | 7 | |
| | | 572 | | 1 | | 19 5<br>11 sand.<br>20 0 | 0 00 | 7 | |
| | | 573 | | 1 | | 19 3<br>13 sand.<br>20 0 | 0 00 | 7 | |
| | | 574 | | 1 | | 19 4<br>12 sand.<br>20 0 | 0 00 | 7 | |
| | | 575 | | 1 | | 19 4<br>12 sand.<br>20 0 | 0 00 | 7 | |
| | | 576 | | 1 | | 19 5<br>11 sand.<br>20 0 | 0 00 | 7 | |
| | | 577 | | 1 | | 19 3<br>13 sand.<br>20 0 | 0 00 | 7 | |
| | | 578 | | 1 | | 19 2<br>14 sand.<br>20 0 | 0 00 | 7 | |
| | | 579 | | 1 | | 19 3<br>13 sand.<br>20 0 | 0 00 | 7 | |
| | | 580 | | 1 | | 19 5<br>11 sand.<br>20 0 | 0 00 | 7 | |

*Watervliet Arsenal, at Sandy Hook, N. J., February 24, 1891.*

**mortar for endurance.]**

| | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|
| **Mortar** mounted on new experimental steel carriage made at Watervliet Arsenal. Cannon friction primers, model of 1887. | |
| | Mortar turned over on left side.<br>Mortar recoiled off platform. |
| Mortar carriage standing on platform of 3-inch spruce plank, 15 feet long, and inclined upward to the rear at an angle of 11 degrees.<br>Fired into field butt, section 2.<br>Recoil restrained by $2\frac{1}{2}$-inch rope, arranged as in previous firing. Rope allowed recoil of 9 feet.<br>Powder loose in chamber. | |
| | Breech and block wiped and oiled. |
| | Breech and block wiped and oiled. |

[Object of firing, to test mortar.

| Date. | | No. of fire. | Powder. | | Projectile. | | Elevation. | Recoil. | Wind, strength and direction. |
|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1891. | | | | *Pounds.* | | *Lbs. Oz.* | ° ′ | *Feet.* | |
| Feb. 18 | A. M...... | 581 | Du Pont's I. K. H. Lot 7. Density, 1.725. Granulation, 2,943. | 1 | Shell (banded), experimental. Lot 249. | 19 2<br>14 sand.<br>20 0 | 0 00 | 7 | From right and rear, 29 miles an hour. |
| | | 582 | | 1 | | 19 2<br>14 sand.<br>20 0 | 0 00 | 7 | |
| | | 583 | | 1 | | 19 1<br>15 sand.<br>20 0 | 0 00 | 7 | |
| | | 584 | | 1 | | 19 1<br>15 sand.<br>20 0 | 0 00 | 7 | |

[Object of firing,

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Feb. 18 | A. M...... | 585 | Du Pont's I. K. H. Lot 7. Density, 1.725. Granulation, 2,943. | 1 | Shell (banded), experimental. Lot 249. | 19 2<br>14 sand<br>20 0 | 0 00 | 7 | From right and rear, 29 miles an hour. |
| | | 586 | | 1 | | 19 2<br>14 sand.<br>20 0 | 0 00 | 7 | |
| | | 587 | | 1 | | 19 3<br>13 sand.<br>20 0 | 0 00 | 7 | |
| | | 588 | | 1 | | 19 1<br>15 sand.<br>20 0 | 0 00 | 7 | |
| | | 589 | | 1 | | 19 3<br>13 sand.<br>20 0 | 0 00 | 7 | |
| | | 590 | | 1 | | 19 1<br>15 sand.<br>20 0 | 0 00 | 7 | |
| | | 591 | | 1 | | 19 2<br>14 sand.<br>20 0 | 0 00 | 7 | |
| | | 592 | | 1 | | 19 3<br>13 sand.<br>20 0 | 0 00 | 7 | |
| | | 593 | | 1 | | 19 3<br>13 sand.<br>20 0 | 0 00 | 7 | |
| | | 594 | | 1 | | 19 3<br>13 sand.<br>20 0 | 0 00 | 7 | |

*Arsenal, at Sandy Hook, N. J., February 24, 1891*—Continued.

mortar for endurance.]

| | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|
| Mortar mounted on new experimental steel carriage made at Watervliet Arsenal. Cannon friction primers, model of 1887. | |
| | Vent shield broken off. |
| | Rope allowed recoil of 9 feet. |
| Recoil restrained by 2½-inch rope, arranged as in previous firing.<br>Fired into field butt, section 2.<br>Powder loose in chamber.<br>Elevation of piece increased by shock of discharge at each fire. | |
| | Rope allowed recoil of 10 feet. Five hundredth round with full charge. |
| | Mortar fell forward on face.<br>Mortar fell forward on face. |
| | Mortar turned over on right side. |
| Condition of mortar after completion of test: Front sight bent and partly unscrewed. Carrying bolts in trunnions partly unscrewed. One lever handle bent. Arc of elevating apparatus worn smooth by clamps. Vent shield broken.<br>Firing conducted by Lieut. O. M. Lissak, O. D., assistant proof officer. Mortar star gauged after round 694, February 24, 1891, by Lieut. O. M. Lissak, O. D. | |

ORMOND M. LISSAK,
*Lieutenant Ordnance Department, Recorder.*

*Star-gauging of 3.6-inch B. L. field mortar, No. 1, Watervliet Arsenal, at Sandy Hook, N. J., August 12, 1890.*

| Inches from breech. | After 90 rounds, chamber. | Inches from muzzle. | After 90 rounds, lands. | Inches from muzzle. | After 90 rounds, lands. | Inches from muzzle. | After 90 rounds, lands. | Inches from muzzle. | After 90 rounds, lands. |
|---|---|---|---|---|---|---|---|---|---|
| 6¼ | 3.809 | ½ | 3.607 | 4 | 3.606 | 7½ | 3.607 | 11 | 3.623 |
| 6¾ | 3.809 | 1 | 3.607 | 4½ | 3.606 | 8 | 3.608 | 11½ | 3.626 |
| 7¼ | 3.809 | 1½ | 3.607 | 5 | 3.606 | 8½ | 3.610 | 12 | 3.628 |
| 7¾ | 3.809 | 2 | 3.6065 | 5½ | 3.606 | 9 | 3.6115 | 12½ | 3.632 |
| 8¼ | 3.809 | 2½ | 3.606 | 6 | 3.606 | 9½ | 3.6155 | 13 | 3.634 |
| 8¾ | 3.809 | 3 | 3.606 | 6½ | 3.6065 | 10 | 3.618 | 13½ | 3.637 |
| 9¼ | 3.809 | 3½ | 3.606 | 7 | 3.6065 | 10½ | 3.6205 | 14 | 3.638 |

*Star-gauging of 3.6-inch B. L. field mortar (steel), No. 1, Watervliet Arsenal, at Sandy Hook, N. J., November 26, 1890.*

| Inches from muzzle. | After round 222, lands. | Inches from muzzle. | After round 222, lands. | Inches from muzzle. | After round 222, lands. | Inches from muzzle. | After round 222, lands. | Inches from breech. | After round 222, chamber vertical. |
|---|---|---|---|---|---|---|---|---|---|
| ½ | 3.609 | 4 | 3.6075 | 7½ | 3.6110 | 11 | 3.6250 | 6¼ | 3.809 |
| 1 | 3.6085 | 4½ | 3.608 | 8 | 3.6115 | 11½ | 3.6275 | 6¾ | 3.809 |
| 1½ | 3.608 | 5 | 3.6085 | 8½ | 3.0125 | 12 | 3.6300 | 7¼ | 3.809 |
| 2 | 3.608 | 5½ | 3.609 | 9 | 3.6150 | 12½ | 3.6325 | 7¾ | 3.809 |
| 2½ | 3.608 | 6 | 3.609 | 9½ | 3.6175 | 13 | 3.6350 | 8¼ | 3.809 |
| 3 | 3.6075 | 6½ | 3.6100 | 10 | 3.6195 | 13½ | 3.6380 | 8¾ | 3.809 |
| 3½ | 3.6075 | 7 | 3.6105 | 10½ | 3.6225 | 14 | 3.6390 | 9¼ | 3.8095 |

*Star-gauging of 3.6-inch B. L. field mortar (steel), No. 1, Watervliet Arsenal, at Sandy Hook, N. J., January 30, 1891.*

| Inches from muzzle. | After round 378, lands. | Inches from muzzle. | After round 378, lands. | Inches from muzzle. | After round 378, lands. | Inches from breech. | After round 378, chamber. |
|---|---|---|---|---|---|---|---|
| ½ | 3.610 | 5 | 3.6085 | 9½ | 3.617 | 6¼ | 3.809 |
| 1 | 3.609 | 5½ | 3.609 | 10 | 3.619 | 7¾ | 3.809 |
| 1½ | 3.6085 | 6 | 3.6095 | 10½ | 3.621 | 9¼ | 3.810 |
| 2 | 3.608 | 6½ | 3.610 | 11 | 3.624 | | |
| 2½ | 3.608 | 7 | 3.610 | 11½ | 3.627 | | |
| 3 | 3.608 | 7½ | 3.611 | 12 | 3.629 | | |
| 3½ | 3.608 | 8 | 3.612 | 12½ | 3.632 | | |
| 4 | 3.6085 | 8½ | 3.613 | 13 | 3.635 | | |
| 4½ | 3.6085 | 9 | 3.614 | 13½ | 3.638 | | |

*Star-gauging of 3.6-inch B. L. field mortar (steel), No. 1, Watervliet Arsenal, at Sandy Hook, N. J., February 13, 1891.*

| Inches from muzzle. | After round 488, lands. | Inches from muzzle. | After round 488, lands. | Inches from muzzle. | After round 488, lands. | Inches from muzzle. | After round 488, chamber. |
|---|---|---|---|---|---|---|---|
| ½ | 3.611 | 5 | 3.610 | 9½ | 3.6185 | 6¼ | 3.809 |
| 1 | 3.610 | 5½ | 3.6105 | 10 | 3.621 | 7¾ | 3.809 |
| 1½ | 3.610 | 6 | 3.611 | 10½ | 3.624 | 9¼ | 3.810 |
| 2 | 3.610 | 6½ | 3.611 | 11 | 3.627 | | |
| 2½ | 3.609 | 7 | 3.612 | 11½ | 3.629 | | |
| 3 | 3.610 | 7½ | 3.612 | 12 | 3.6305 | | |
| 3½ | 3.609 | 8 | 3.613 | 12½ | 3.633 | | |
| 4 | 3.010 | 8½ | 3.614 | 13 | 3.636 | | |
| 4½ | 3.610 | 9 | 3.017 | 13½ | 3.639 | | |

*Star-gauging of 3.6-inch B. L. field mortar (steel), No. 1, Waterrliet Arsenal, at Sandy Hook, N. J., February 18, 1891.*

| Inches from muzzle. | After round 594, lands. | Inches from muzzle. | After round 594, lands. | Inches from muzzle. | After round 594, lands. | Inches from breech. | After round 594, chamber. |
|---|---|---|---|---|---|---|---|
| ½ | 3.613 | 5 | 3.612 | 9½ | 3.619 | 6½ | 3.81 |
| 1 | 3.612 | 5½ | 3.6115 | 10 | 3.621 | 7½ | 3.81 |
| 1½ | 3.6115 | 6 | 3.6125 | 10½ | 3.624 | 9½ | 3.8105 |
| 2 | 3.6115 | 6½ | 3.613 | 11 | 3.627 | | |
| 2½ | 3.611 | 7 | 3.613 | 11½ | 3.6285 | | |
| 3 | 3.611 | 7½ | 3.614 | 12 | 3.631 | | |
| 3½ | 3.611 | 8 | 3.614 | 12½ | 3.633 | | |
| 4 | 3.611 | 8½ | 3.6155 | 13 | 3.637 | | |
| 4½ | 3.611 | 9 | 3.617 | 13½ | 3.639 | | |

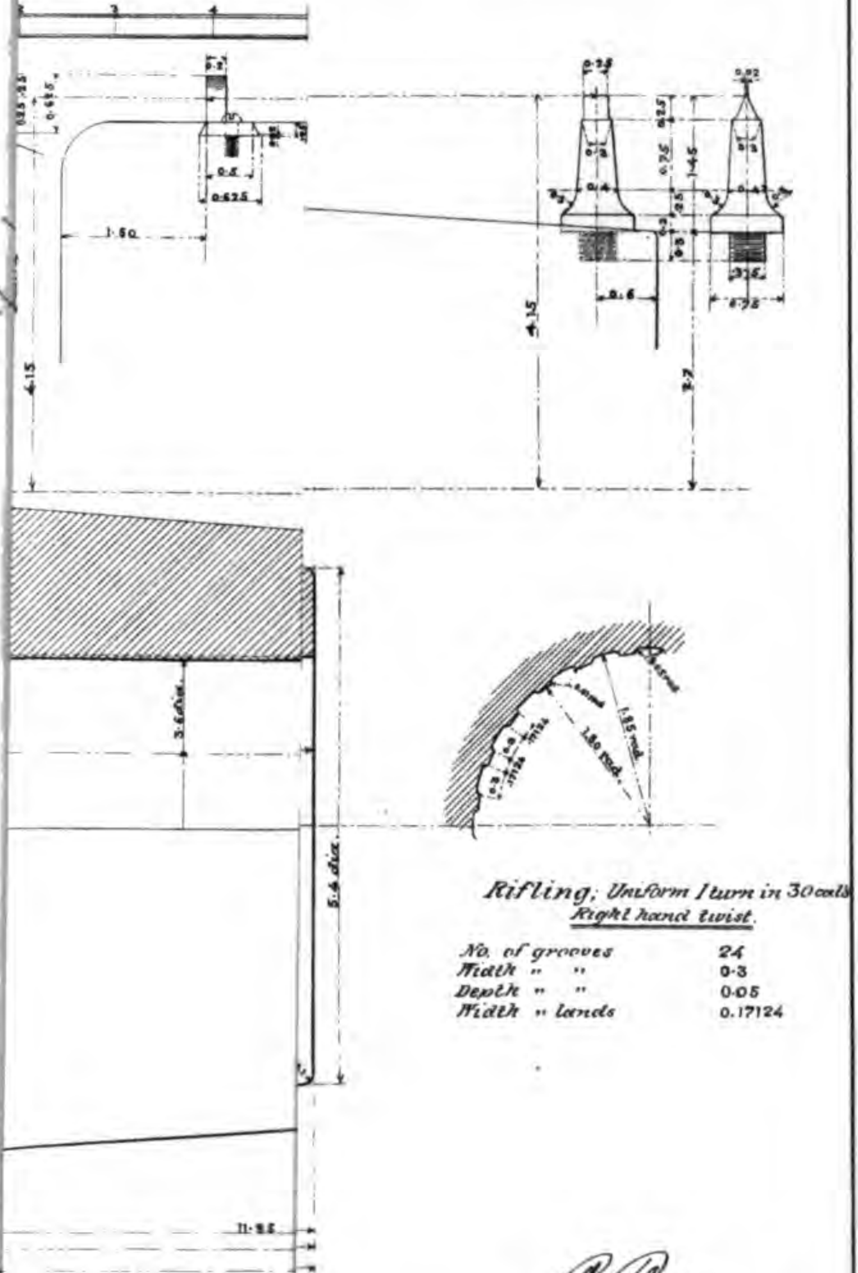
*Star-gauging of 3.6-inch B. L. mortar (steel), No. 1, Waterrliet Arsenal, at Sandy Hook, N. J., February 24, 1891.*

| Inches from muzzle. | After round 694, lands. | Inches from muzzle. | After round 694, lands. | Inches from muzzle. | After round 694, lands. | Inches from breech. | After round 694, chamber. |
|---|---|---|---|---|---|---|---|
| ½ | 3.616 | 5 | 3.6145 | 9½ | 3.623 | 6½ | 3.811 |
| 1 | 3.615 | 5½ | 3.615 | 10 | 3.624 | 7½ | 3.811 |
| 1½ | 3.615 | 6 | 3.6155 | 10½ | 3.627 | 9½ | 3.812 |
| 2 | 3.615 | 6½ | 3.616 | 11 | 3.6295 | | |
| 2½ | 3.615 | 7 | 3.616 | 11½ | 3.6315 | | |
| 3 | 3.6145 | 7½ | 3.6165 | 12 | 3.6335 | | |
| 3½ | 3.6145 | 8 | 3.617 | 12½ | 3.636 | | |
| 4 | 3.6145 | 8½ | 3.618 | 13 | 3.6385 | | |
| 4½ | 3.6145 | 9 | 3.620 | 13½ | 3.6405 | | |

| Date. | | No. of fire. | Powder. | | Projectile. | | Including sand. | Elevation. | Recoil. | Wind, strength and direction. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Wgt. | Kind. | Wgt. | | | | |
| 1891. | | | | *Lbs.* | | *Lbs.* | *Lbs. Oz.* | ° ′ | *Feet.* | |
| Feb. 24 | A. M ....... | 666 | DuPont's I. K. H. Lot 8. Density, 1.725. Granulation, 2,630. | 1 | Shell (banded), experimental. Lot 249. | 20 | 14 | 0 00 | 9 | From right and front, 9 miles an hour. |
| | | 667 | | 1 | | 20 | 11 | 0 00 | 9 | |
| | | 668 | | 1 | | 20 | 11 | 0 00 | 9 | |
| | | 669 | | 1 | | 20 | 14 | 0 00 | 9 | |
| | | 670 | | 1 | | 20 | 13 | 0 00 | 9 | |
| | | 671 | | 1 | | 20 | 14 | 0 00 | 9 | |
| | | 672 | | 1 | | 20 | 16 | 0 00 | 9 | |
| | | 673 | | 1 | | 20 | 13 | 0 00 | 9 | |
| | | 674 | | 1 | | 20 | 15 | 0 00 | 9 | |
| | | 675 | | 1 | | 20 | 15 | 0 00 | 9 | |
| | | 676 | | 1 | | 20 | 1 1 | 0 00 | 9 | |
| | | 677 | | 1 | | 20 | 14 | 0 00 | 9 | |
| | | 678 | | 1 | | 20 | 13 | 0 00 | 9 | |
| | | 679 | | 1 | | 20 | 14 | 0 00 | 9 | |
| | | 680 | | 1 | | 20 | 15 | 0 00 | 9 | |
| | | 681 | | 1 | | 20 | 11 | 0 00 | 9 | |
| | | 682 | | 1 | | 20 | 14 | 0 00 | 9 | |
| | | 683 | DuPont's I. K. H. Lot 11. Density, 1.725. Granulation, 2,459. | 1 | | 20 | 15 | 0 00 | 9 | |
| | | 684 | | 1 | | 20 | 15 | 0 00 | 9 | |
| | | 685 | | 1 | | 20 | 14 | 0 00 | 9 | |
| | | 686 | | 1 | | 20 | 14 | 0 00 | 9 | |
| | | 687 | | 1 | | 20 | 15 | 0 00 | 9 | |
| | | 688 | | 1 | | 20 | 13 | 0 00 | 9 | |
| | | 689 | | 1 | | 20 | 1 0 | 0 00 | 9 | |
| | | 690 | | 1 | | 20 | 15 | 0 00 | 9 | |
| | | 691 | | 1 | | 20 | 14 | 0 00 | 9 | |
| | | 692 | | 1 | | 20 | 13 | 0 00 | 9 | |
| | | 693 | | 1 | | 20 | 13 | 0 00 | 9 | |
| | | 694 | | 1 | | 20 | 12 | 0 00 | 9 | |
| Feb. 24 | P. M ....... | 695 | | 1 | | 20 | 14 | 0 00 | 10 | |
| | | 696 | | 1 | | 20 | 14 | 0 00 | 10 | |
| | | 697 | | 1 | | 20 | 14 | 0 00 | 10 | |
| | | 698 | | 1 | | 20 | 1 0 | 0 00 | 10 | |
| | | 699 | | 1 | | 20 | 15 | 0 00 | 10 | |
| | | 700 | | 1 | | 20 | 14 | 0 00 | 10 | |
| | | 701 | | 1 | | 20 | 14 | 0 00 | 10 | |
| | | 702 | | 1 | | 20 | 11 | 0 00 | 10 | |
| | | 703 | | 1 | | 20 | 11 | 0 00 | 10 | |
| | | 704 | | 1 | | 20 | 13 | 0 00 | 10 | |
| | | 705 | | 1 | | 20 | 12 | 0 00 | 10 | |
| | | 706 | | 1 | | 20 | 12 | 0 00 | 10 | |
| | | 707 | | 1 | | 20 | 14 | 0 00 | 10 | |
| | | 708 | | 1 | | 20 | 14 | 0 00 | 10 | |
| | | 709 | | 1 | | 20 | 15 | 0 00 | 10 | |
| | | 710 | | 1 | | 20 | 14 | 0 00 | 10 | |
| | | 711 | | 1 | | 20 | 14 | 0 00 | 10 | |
| | | 712 | | 1 | | 20 | 13 | 0 00 | 10 | |
| | | 713 | | 1 | | 20 | 14 | 0 00 | 10 | |
| | | 714 | | 1 | | 20 | 14 | 0 00 | 10 | |

A. MORDECAI,
*Colonel Ordnance Department, U. S. A., President of the Board.*

# MORTAR, S



*Rifling; Uniform 1 turn in 30 cals*
*Right hand twist.*

| | |
|---|---|
| *No. of grooves* | 24 |
| *Width " "* | 0·3 |
| *Depth " "* | 0·05 |
| *Width " lands* | 0.17124 |

R. Birnie

*Captain Ordnance Dep't.*

| Inches from breech. | After 90 rounds, chamber. | Inches from muzzle. | After 90 rounds, lands. | Inches from muzzle. | After 90 rounds, lands. | Inches from muzzle. | After 90 rounds, lands. | Inches from muzzle. | After 90 rounds, lands. |
|---|---|---|---|---|---|---|---|---|---|
| 6¼ | 3.809 | ½ | 3.607 | 4 | 3.606 | 7½ | 3.607 | 11 | 3.623 |
| 6¾ | 3.809 | 1 | 3.607 | 4½ | 3.606 | 8 | 3.608 | 11½ | 3.626 |
| 7¼ | 3.809 | 1½ | 3.607 | 5 | 3.606 | 8½ | 3.610 | 12 | 3.628 |
| 7¾ | 3.809 | 2 | 3.6065 | 5½ | 3.606 | 9 | 3.6115 | 12½ | 3.632 |
| 8¼ | 3.809 | 2½ | 3.606 | 6 | 3.606 | 9½ | 3.6155 | 13 | 3.634 |
| 8¾ | 3.809 | 3 | 3.606 | 6½ | 3.6065 | 10 | 3.618 | 13½ | 3.637 |
| 9¼ | 3.809 | 3½ | 3.606 | 7 | 3.6065 | 10½ | 3.6205 | 14 | 3.628 |

*Star-gauging of 3.6-inch B. L. field mortar (steel), No. 1, Watervliet Arsenal, at Sandy Hook, N. J., November 26, 1890.*

| Inches from muzzle. | After round 222, lands. | Inches from muzzle. | After round 222, lands. | Inches from muzzle. | After round 222, lands. | Inches from muzzle. | After round 222, lands. | Inches from breech. | After round 222, chamber vertical. |
|---|---|---|---|---|---|---|---|---|---|
| ½ | 3.609 | 4 | 3.6075 | 7½ | 3.6110 | 11 | 3.6250 | 6¼ | 3.809 |
| 1 | 3.6085 | 4½ | 3.608 | 8 | 3.6115 | 11½ | 3.6275 | 6¾ | 3.809 |
| 1½ | 3.608 | 5 | 3.6085 | 8½ | 3.6125 | 12 | 3.6300 | 7¼ | 3.809 |
| 2 | 3.608 | 5½ | 3.609 | 9 | 3.6150 | 12½ | 3.6325 | 7¾ | 3.809 |
| 2½ | 3.608 | 6 | 3.609 | 9½ | 3.6175 | 13 | 3.6350 | 8¼ | 3.809 |
| 3 | 3.6075 | 6½ | 3.6100 | 10 | 3.6195 | 13½ | 3.6380 | 8¾ | 3.809 |
| 3½ | 3.6075 | 7 | 3.6105 | 10½ | 3.6225 | 14 | 3.6390 | 9¼ | 3.8095 |

*Star-gauging of 3.6-inch B. L. field mortar (steel), No. 1, Watervliet Arsenal, at Sandy Hook, N. J., January 30, 1891.*

| Inches from muzzle. | After round 378, lands. | Inches from muzzle. | After round 378, lands. | Inches from muzzle. | After round 378, lands. | Inches from breech. | After round 378, chamber. |
|---|---|---|---|---|---|---|---|
| ½ | 3.610 | 5 | 3.6085 | 9½ | 3.617 | 6¼ | 3.809 |
| 1 | 3.609 | 5½ | 3.609 | 10 | 3.619 | 7¾ | 3.809 |
| 1½ | 3.6085 | 6 | 3.6095 | 10½ | 3.621 | 9¼ | 3.810 |
| 2 | 3.608 | 6½ | 3.610 | 11 | 3.624 | | |
| 2½ | 3.608 | 7 | 3.610 | 11½ | 3.627 | | |
| 3 | 3.608 | 7½ | 3.611 | 12 | 3.629 | | |
| 3½ | 3.608 | 8 | 3.612 | 12½ | 3.632 | | |
| 4 | 3.6085 | 8½ | 3.613 | 13 | 3.635 | | |
| 4½ | 3.6085 | 9 | 3.614 | 13½ | 3.638 | | |

*Star-gauging of 3.6-inch B. L. field mortar (steel), No. 1, Watervliet Arsenal, at Sandy Hook, N. J., February 13, 1891.*

| Inches from muzzle. | After round 488, lands. | Inches from muzzle. | After round 488, lands. | Inches from muzzle. | After round 488, lands. | Inches from muzzle. | After round 488, chamber. |
|---|---|---|---|---|---|---|---|
| ½ | 3.611 | 5 | 3.610 | 9½ | 3.6185 | 6¼ | 3.809 |
| 1 | 3.610 | 5½ | 3.6105 | 10 | 3.621 | 7¾ | 3.809 |
| 1½ | 3.610 | 6 | 3.611 | 10½ | 3.624 | 9¼ | 3.810 |
| 2 | 3.610 | 6½ | 3.611 | 11 | 3.627 | | |
| 2½ | 3.609 | 7 | 3.612 | 11½ | 3.629 | | |
| 3 | 3.610 | 7½ | 3.612 | 12 | 3.6305 | | |
| 3½ | 3.609 | 8 | 3.613 | 12½ | 3.633 | | |
| 4 | 3.610 | 8½ | 3.614 | 13 | 3.636 | | |
| 4½ | 3.610 | 9 | 3.617 | 13½ | 3.639 | | |

| Inches from muzzle. | After round 594, lands. | Inches from muzzle. | After round 594, lands. | Inches from muzzle. | After round 594, lands. | Inches from breech. | After round 594, chamber. |
|---|---|---|---|---|---|---|---|
| ½ | 3.613 | 5 | 3.612 | 9½ | 3.619 | 6¼ | 3.81 |
| 1 | 3.612 | 5½ | 3.6115 | 10 | 3.621 | 7¾ | 3.81 |
| 1½ | 3.6115 | 6 | 3.6125 | 10½ | 3.624 | 9¼ | 3.8105 |
| 2 | 3.6115 | 6½ | 3.613 | 11 | 3.627 | | |
| 2½ | 3.611 | 7 | 3.613 | 11½ | 3.6285 | | |
| 3 | 3.611 | 7½ | 3.614 | 12 | 3.631 | | |
| 3½ | 3.611 | 8 | 3.614 | 12½ | 3.633 | | |
| 4 | 3.611 | 8½ | 3.6155 | 13 | 3.637 | | |
| 4½ | 3.611 | 9 | 3.617 | 13½ | 3.639 | | |

*Star-gauging of 3.6-inch B. L. mortar (steel), No. 1, Watervliet Arsenal, at Sandy Hook, N. J., February 24, 1891.*

| Inches from muzzle. | After round 694, lands. | Inches from muzzle. | After round 694, lands. | Inches from muzzle. | After round 694, lands. | Inches from breech. | After round 694, chamber. |
|---|---|---|---|---|---|---|---|
| ½ | 3.616 | 5 | 3.6145 | 9½ | 3.623 | 6¼ | 3.811 |
| 1 | 3.615 | 5½ | 3.615 | 10 | 3.624 | 7¾ | 3.811 |
| 1½ | 3.615 | 6 | 3.6155 | 10½ | 3.627 | 9¼ | 3.812 |
| 2 | 3.615 | 6½ | 3.616 | 11 | 3.6295 | | |
| 2½ | 3.615 | 7 | 3.616 | 11½ | 3.6315 | | |
| 3 | 3.6145 | 7½ | 3.6165 | 12 | 3.6335 | | |
| 3½ | 3.6145 | 8 | 3.617 | 12½ | 3.636 | | |
| 4 | 3.6145 | 8½ | 3.618 | 13 | 3.6385 | | |
| 4½ | 3.6145 | 9 | 3.620 | 13½ | 3.6405 | | |

No. 1

, N. J.
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from Gun.

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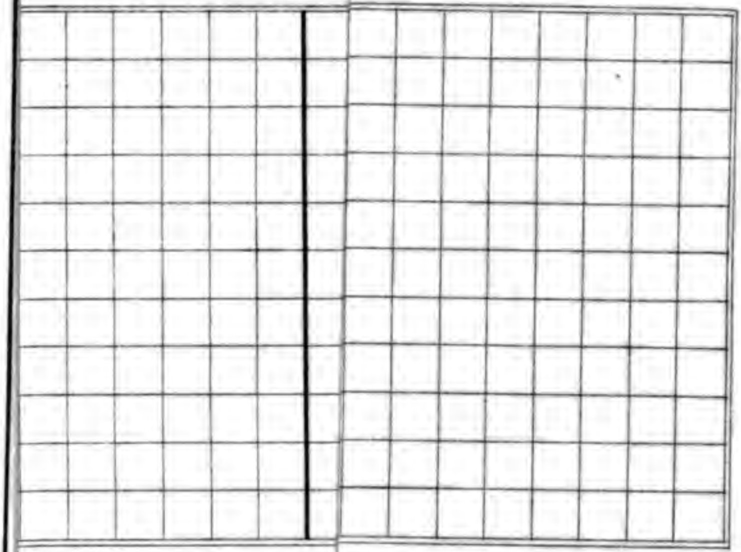

O. M. Lissak
Ord. Dept.

el) N°1

K, N. J.

9th 1891

*from Gun.*

r of ***hits:***

Orm. M. Lissak

Lieu Dept.

Steel) No 1

K, N. J.

ary 9 th 1891

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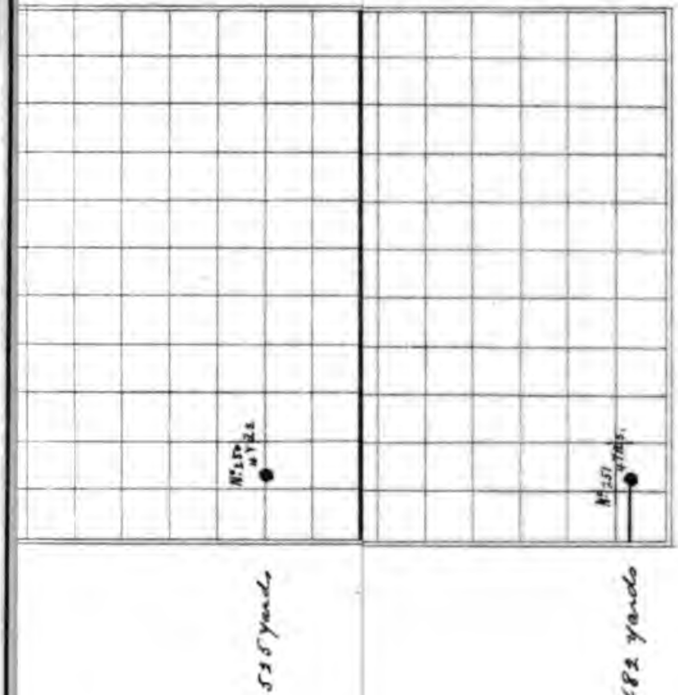

diet

M. Lissak

d. Dept.

teel) No.1

OK, N. J.
9th 1891.

from G

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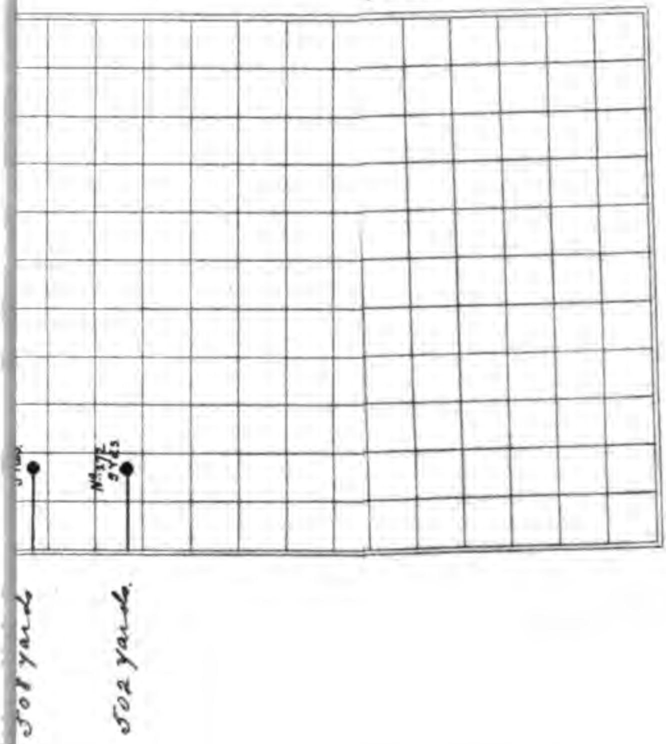


Lt. Det.

M. Lissak

Dept.

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1, Waterrliet*

[Object of firing, to test mortar

| Date. | | No. of fire. | Powder. | | Projectile. | | Elevation. | Recoil. | Wind strength and direction. |
|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Weight. | Kind. | Weight. | | | |
| 1891. | | | | *Pounds.* | | *Lbs. Oz.* | ° ′ | *Feet.* | |
| Feb. 18 | A. M ...... | 581 | Du Pont's I. K. H. Lot 7. Density, 1.725. Granulation, 2,943. | 1 | Shell (banded), experimental. Lot 249. | 19 2<br>14 sand.<br>20 0 | 0 00 | 7 | From right and rear, 29 miles an hour. |
| | | 582 | | 1 | | 19 2<br>14 sand.<br>20 0 | 0 00 | 7 | |
| | | 583 | | 1 | | 19 1<br>15 sand.<br>20 0 | 0 00 | 7 | |
| | | 584 | | 1 | | 19 1<br>15 sand.<br>20 0 | 0 00 | 7 | |

[Object of firin

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Feb. 18 | A. M ...... | 585 | Du Pont's I. K. H. Lot 7. Density, 1.725. Granulation, 2,943. | 1 | Shell (banded), experimental. Lot 249. | 19 2<br>14 sand<br>20 0 | 0 00 | 7 | From right and rear, 29 miles an hour |
| | | 586 | | 1 | | 19 2<br>14 sand.<br>20 0 | 0 00 | 7 | |
| | | 587 | | 1 | | 19 3<br>13 sand.<br>20 0 | 0 00 | 7 | |
| | | 588 | | 1 | | 19 1<br>15 sand.<br>20 0 | 0 00 | 7 | |
| | | 589 | | 1 | | 19 3<br>13 sand.<br>20 0 | 0 00 | 7 | |
| | | 590 | | 1 | | 19 1<br>15 sand.<br>20 0 | 0 00 | 7 | |
| | | 591 | | 1 | | 19 2<br>14 sand.<br>20 0 | 0 00 | 7 | |
| | | 592 | | 1 | | 19 3<br>13 sand.<br>20 0 | 0 00 | 7 | |
| | | 593 | | 1 | | 19 3<br>13 sand.<br>20 0 | 0 00 | 7 | |
| | | 594 | | 1 | | 19 3<br>13 sand.<br>20 0 | 0 00 | 7 | |

rsenal, *at Sandy Hook, N. J., February 18, 1891*—Continued.

r rapidity and endurance.]

| | Special remarks about each fir on piece, action of breech n sumption of powder, sound flight, scattering of fragmen trological data. |
|---|---|
| Cannon friction primers, model of 1887. | Mortar turned over on right si |
| Powder loose in chamber.<br>Fired into field butt, No. 2.<br>Time occupied in firing 10 rounds (575 to 584), 13 minutes and 30 seconds. | |
| | Mortar turned over. |

special rapidity test.]

| | |
|---|---|
| Cannon friction primers, model of 1887. | |
| Powder loose in chamber.<br>Gun detachment consisted of 1 noncommissioned officer and 2 men.<br>Fired into field butt, No. 2.<br>Time occupied in firing 10 rounds (585 to 594), 6 minutes and 50 seconds.<br>Total time occupied in firing 50 rounds, 56 minutes and 25 seconds, including delay of 3 minutes and 10 seconds. | |
| Firing conducted by Lieut. O. M. Lissak, O. D., assistant proof officer.<br>Mortar star gauged after round 594, February 18, 1891, by Lieut. O. M. Lissak, O. D. | |

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1,*

[Object of firing, to te

| Date. | | No. of fire. | Powder. | | Projectile. | | Including sand. | Elevation. | Recoil. | Wind, strength and direction. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Wgt. | Kind. | Wgt. | | | | |
| 1891. | | | | *Lbs.* | | *Lbs.* | *Lbs. Oz.* | ° ′ | *Feet.* | |
| Feb. 24 | A. M....... | 595 | Lot 7. Density, 1.725. Granulation, 2,500. | 1 | Shell (banded), experimental. Lot 249. | 20 | 1 0 | 0 00 | ........ | From right and front, 9 miles an hour. |
| | | 596 | | 1 | | 20 | 14 | 0 00 | ........ | |
| | | 597 | | 1 | | 20 | 13 | 0 00 | 9 | |
| | | 598 | | 1 | | 20 | 14 | 0 00 | 9 | |
| | | 599 | Lot 12. Density, 1.725. Granulation, 2,510. | 1 | | 20 | 15 | 0 00 | 9 | |
| | | 600 | | 1 | | 20 | 12 | 0 00 | 9 | |
| | | 601 | | 1 | | 20 | 15 | 0 00 | 9 | |
| | | 602 | | 1 | | 20 | 14 | 0 00 | 9 | |
| | | 603 | Du Pont's I. K. H. Lot 9. Density, 1.725. Granulation, 2,532. | 1 | | 20 | 15 | 0 00 | 9 | |
| | | 604 | | 1 | | 20 | 14 | 0 00 | 9 | |
| | | 605 | | 1 | | 20 | 13 | 0 00 | 9 | |
| | | 606 | | 1 | | 20 | 14 | 0 00 | 9 | |
| | | 607 | | 1 | | 20 | 15 | 0 00 | 9 | |
| | | 608 | | 1 | | 20 | 15 | 0 00 | 9 | |
| | | 609 | | 1 | | 20 | 14 | 0 00 | 9 | |
| | | 610 | | 1 | | 20 | 14 | 0 00 | 9 | |
| | | 611 | | 1 | | 20 | 14 | 0 00 | 9 | |
| | | 612 | | 1 | | 20 | 12 | 0 00 | 9 | |
| | | 613 | | 1 | | 20 | 11 | 0 00 | 9 | |
| | | 614 | | 1 | | 20 | 11 | 0 00 | 9 | |
| | | 615 | | 1 | | 20 | 15 | 0 00 | 9 | |
| | | 616 | | 1 | | 20 | 14 | 0 00 | 9 | |
| | | 617 | | 1 | | 20 | 15 | 0 00 | 9 | |
| | | 618 | | 1 | | 20 | 13 | 0 00 | 9 | |
| | | 619 | | 1 | | 20 | 15 | 0 00 | 9 | |
| | | 620 | | 1 | | 20 | 15 | 0 00 | 9 | |
| | | 621 | | 1 | | 20 | 15 | 0 00 | 9 | |
| | | 622 | | 1 | | 20 | 16 | 0 00 | 9 | |
| | | 623 | | 1 | | 20 | 15 | 0 00 | 9 | |
| | | 624 | | 1 | | 20 | 14 | 0 00 | 9 | |
| | | 625 | | 1 | | 20 | 15 | 0 00 | 9 | |
| | | 626 | | 1 | | 20 | 10 | 0 00 | 9 | |
| | | 627 | | 1 | | 20 | 14 | 0 00 | 9 | |
| | | 628 | | 1 | | 20 | 11 | 0 00 | 9 | |
| | | 629 | | 1 | | 20 | 10 | 0 00 | 9 | |
| | | 630 | | 1 | | 20 | 15 | 0 00 | 9 | |
| | | 631 | | 1 | | 20 | 11 | 0 00 | 9 | |
| | | 632 | | 1 | | 20 | 14 | 0 00 | 9 | |
| | | 633 | | 1 | | 20 | 14 | 0 00 | 9 | |
| | | 634 | | 1 | | 20 | 14 | 0 00 | 9 | |
| | | 635 | Du Pont's I. K. H. Lot 10. Density, 1.725. Granulation, 2,586. | 1 | | 20 | 11 | 0 00 | 9 | |
| | | 636 | | 1 | | 20 | 12 | 0 00 | 9 | |
| | | 637 | | 1 | | 20 | 14 | 0 00 | 9 | |
| | | 638 | | 1 | | 20 | 11 | 0 00 | 9 | |
| | | 639 | | 1 | | 20 | 15 | 0 00 | 9 | |
| | | 640 | | 1 | | 20 | 12 | 0 00 | 9 | |
| | | 641 | | 1 | | 20 | 13 | 0 00 | 9 | |
| | | 642 | | 1 | | 20 | 13 | 0 00 | 9 | |
| | | 643 | | 1 | | 20 | 12 | 0 00 | 9 | |
| | | 644 | | 1 | | 20 | 15 | 0 00 | 9 | |
| | | 645 | | 1 | | 20 | 13 | 0 00 | 9 | |
| | | 646 | | 1 | | 20 | 14 | 0 00 | 9 | |
| | | 647 | | 1 | | 20 | 13 | 0 00 | 9 | |
| | | 648 | | 1 | | 20 | 13 | 0 00 | 9 | |
| | | 649 | | 1 | | 20 | 14 | 0 00 | 9 | |
| | | 650 | | 1 | | 20 | 14 | 0 00 | 9 | |
| | | 651 | | 1 | | 20 | 14 | 0 00 | 9 | |
| | | 652 | | 1 | | 20 | 13 | 0 00 | 9 | |
| | | 653 | | 1 | | 20 | 14 | 0 00 | 9 | |
| | | 654 | | 1 | | 20 | 13 | 0 00 | 9 | |
| | | 655 | | 1 | | 20 | 1 1 | 0 00 | 9 | |
| | | 656 | | 1 | | 20 | 15 | 0 00 | 9 | |
| | | 657 | | 1 | | 20 | 13 | 0 00 | 9 | |
| | | 658 | | 1 | | 20 | 14 | 0 00 | 9 | |
| | | 659 | | 1 | | 20 | 15 | 0 00 | 9 | |
| | | 660 | | 1 | | 20 | 14 | 0 00 | 9 | |
| | | 661 | | 1 | | 20 | 13 | 0 00 | 9 | |
| | | 662 | | 1 | | 20 | 15 | 0 00 | 9 | |
| | | 663 | | 1 | | 20 | 15 | 0 00 | 9 | |
| | | 664 | | 1 | | 20 | 13 | 0 00 | 9 | |
| | | 665 | | 1 | | 20 | 15 | 0 00 | 9 | |

*Vatervliet Arsenal, at Sandy Hook, N. J., February 24, 1891.*

**ortar for endurance.]**

| | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|
| Mortar mounted on new experimental steel carriage made at Watervliet Arsenal. Cannon friction primers, model of 1887. | |
| Mortar carriage standing on platform of 3-inch spruce plank, 15 feet long, and inclined upward to the rear at an angle of 11 degrees.<br>Fired into field butt, section 2.<br>Recoil restrained by 2½-inch rope, arranged as in previous firing. Rope allowed recoil of 9 feet.<br>Powder loose in chamber. | Mortar turned over on left side.<br>Mortar recoiled off platform. |
| | Breech and block wiped and oiled. |
| | Breech and block wiped and oiled. |

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1, Watervliet*

[Object of firing, to test

| Date. | | No. of fire. | Powder. | | Projectile. | | Including sand. | | Elevation. | | Recoil. | Wind strength and direction. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Wgt. | Kind. | Wgt. | | | | | | |
| 1891. | | | | Lbs. | | Lbs. | Lbs. | Oz. | ° | ' | Feet. | |
| Feb. 24 | A. M ....... | 666 | DuPont's I. K. H. Lot 8. Density, 1.725. Granulation, 2,630. | 1 | Shell (banded), experimental. Lot 249. | 20 | | 14 | 0 | 00 | 9 | From right and front, 9 miles an hour. |
| | | 667 | | 1 | | 20 | | 11 | 0 | 00 | 9 | |
| | | 668 | | 1 | | 20 | | 11 | 0 | 00 | 9 | |
| | | 669 | | 1 | | 20 | | 14 | 0 | 00 | 9 | |
| | | 670 | | 1 | | 20 | | 13 | 0 | 00 | 9 | |
| | | 671 | | 1 | | 20 | | 14 | 0 | 00 | 9 | |
| | | 672 | | 1 | | 20 | | 16 | 0 | 00 | 9 | |
| | | 673 | | 1 | | 20 | | 13 | 0 | 00 | 9 | |
| | | 674 | | 1 | | 20 | | 15 | 0 | 00 | 9 | |
| | | 675 | | 1 | | 20 | | 15 | 0 | 00 | 9 | |
| | | 676 | | 1 | | 20 | 1 | 1 | 0 | 00 | 9 | |
| | | 677 | | 1 | | 20 | | 14 | 0 | 00 | 9 | |
| | | 678 | | 1 | | 20 | | 13 | 0 | 00 | 9 | |
| | | 679 | | 1 | | 20 | | 14 | 0 | 00 | 9 | |
| | | 680 | | 1 | | 20 | | 15 | 0 | 00 | 9 | |
| | | 681 | | 1 | | 20 | | 11 | 0 | 00 | 9 | |
| | | 682 | | 1 | | 20 | | 14 | 0 | 00 | 9 | |
| | | 683 | DuPont's I. K. H. Lot 11. Density, 1.725. Granulation, 2,459. | 1 | | 20 | | 15 | 0 | 00 | 9 | |
| | | 684 | | 1 | | 20 | | 15 | 0 | 00 | 9 | |
| | | 685 | | 1 | | 20 | | 14 | 0 | 00 | 9 | |
| | | 686 | | 1 | | 20 | | 14 | 0 | 00 | 9 | |
| | | 687 | | 1 | | 20 | | 15 | 0 | 00 | 9 | |
| | | 688 | | 1 | | 20 | | 13 | 0 | 00 | 9 | |
| | | 689 | | 1 | | 20 | 1 | 0 | 0 | 00 | 9 | |
| | | 690 | | 1 | | 20 | | 15 | 0 | 00 | 9 | |
| | | 691 | | 1 | | 20 | | 14 | 0 | 00 | 9 | |
| | | 692 | | 1 | | 20 | | 13 | 0 | 00 | 9 | |
| | | 693 | | 1 | | 20 | | 13 | 0 | 00 | 9 | |
| | | 694 | | 1 | | 20 | | 12 | 0 | 00 | 9 | |
| Feb. 24 | P. M ....... | 695 | | 1 | | 20 | | 14 | 0 | 00 | 10 | |
| | | 696 | | 1 | | 20 | | 14 | 0 | 00 | 10 | |
| | | 697 | | 1 | | 20 | | 14 | 0 | 00 | 10 | |
| | | 698 | | 1 | | 20 | 1 | 0 | 0 | 00 | 10 | |
| | | 699 | | 1 | | 20 | | 15 | 0 | 00 | 10 | |
| | | 700 | | 1 | | 20 | | 14 | 0 | 00 | 10 | |
| | | 701 | | 1 | | 20 | | 14 | 0 | 00 | 10 | |
| | | 702 | | 1 | | 20 | | 11 | 0 | 00 | 10 | |
| | | 703 | | 1 | | 20 | | 11 | 0 | 00 | 10 | |
| | | 704 | | 1 | | 20 | | 13 | 0 | 00 | 10 | |
| | | 705 | | 1 | | 20 | | 12 | 0 | 00 | 10 | |
| | | 706 | | 1 | | 20 | | 12 | 0 | 00 | 10 | |
| | | 707 | | 1 | | 20 | | 14 | 0 | 00 | 10 | |
| | | 708 | | 1 | | 20 | | 14 | 0 | 00 | 10 | |
| | | 709 | | 1 | | 20 | | 15 | 0 | 00 | 10 | |
| | | 710 | | 1 | | 20 | | 14 | 0 | 00 | 10 | |
| | | 711 | | 1 | | 20 | | 14 | 0 | 00 | 10 | |
| | | 712 | | 1 | | 20 | | 13 | 0 | 00 | 10 | |
| | | 713 | | 1 | | 20 | | 14 | 0 | 00 | 10 | |
| | | 714 | | 1 | | 20 | | 14 | 0 | 00 | 10 | |

A. MORDECAI,
*Colonel Ordnance Department, U. S. A., President of the Board.*

*Arsenal, at Sandy Hook, N. J., February 24, 1891*—Continued.

mortar for endurance.]

| | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|
| Mortar mounted on new experimental steel carriage made at Watervliet Arsenal. Cannon friction primers, model of 1887. | |
| | Vent shield broken off. |
| | Rope allowed recoil of 9 feet. |
| Recoil restrained by 2½-inch rope, arranged as in previous firing.<br>Fired into field butt, section 2.<br>Powder loose in chamber.<br>Elevation of piece increased by shock of discharge at each fire. | |
| | Rope allowed recoil of 10 feet. Five hundredth round with full charge. |
| | Mortar fell forward on face. |
| | Mortar fell forward on face. |
| | Mortar turned over on right side. |
| Condition of mortar after completion of test: Front sight bent and partly unscrewed. Carrying bolts in trunnions partly unscrewed. One lever handle bent. Arc of elevating apparatus worn smooth by clamps. Vent shield broken.<br>Firing conducted by Lieut. O. M. Lissak, O. D., assistant proof officer. Mortar star gauged after round 694, February 24, 1891, by Lieut. O. M. Lissak, O. D. | |

ORMOND M. LISSAK,
*Lieutenant Ordnance Department, Recorder.*

*Star-gauging of 3.6-inch B. L. field mortar, No. 1, Watervliet Arsenal, at Sandy Hook, N. J., August 12, 1890.*

| Inches from breech. | After 90 rounds, chamber. | Inches from muzzle. | After 90 rounds, lands. | Inches from muzzle. | After 90 rounds, lands. | Inches from muzzle. | After 90 rounds, lands. | Inches from muzzle. | After 90 rounds, lands. |
|---|---|---|---|---|---|---|---|---|---|
| 6¼ | 3.809 | ½ | 3.607 | 4 | 3.606 | 7½ | 3.607 | 11 | 3.623 |
| 6¾ | 3.809 | 1 | 3.607 | 4½ | 3.606 | 8 | 3.608 | 11½ | 3.626 |
| 7¼ | 3.809 | 1½ | 3.607 | 5 | 3.606 | 8½ | 3.610 | 12 | 3.628 |
| 7¾ | 3.809 | 2 | 3.6065 | 5½ | 3.606 | 9 | 3.6115 | 12½ | 3.632 |
| 8¼ | 3.809 | 2½ | 3.606 | 6 | 3.606 | 9½ | 3.6155 | 13 | 3.634 |
| 8¾ | 3.809 | 3 | 3.606 | 6½ | 3.6065 | 10 | 3.618 | 13½ | 3.637 |
| 9¼ | 3.809 | 3½ | 3.606 | 7 | 3.6065 | 10½ | 3.6205 | 14 | 3 638 |

*Star-gauging of 3.6-inch B. L. field mortar (steel), No. 1, Watervliet Arsenal, at Sandy Hook, N. J., November 26, 1890.*

| Inches from muzzle. | After round 222, lands. | Inches from muzzle. | After round 222, lands. | Inches from muzzle. | After round 222, lands. | Inches from muzzle. | After round 222, lands. | Inches from breech. | After round 222, chamber vertical. |
|---|---|---|---|---|---|---|---|---|---|
| ½ | 3.609 | 4 | 3.6075 | 7½ | 3.6110 | 11 | 3.6250 | 6¼ | 3.809 |
| 1 | 3.6085 | 4½ | 3.608 | 8 | 3.6115 | 11½ | 3.6275 | 6¾ | 3.809 |
| 1½ | 3.608 | 5 | 3.6085 | 8½ | 3.6125 | 12 | 3.6300 | 7¼ | 3.809 |
| 2 | 3.608 | 5½ | 3.609 | 9 | 3.6150 | 12½ | 3.6325 | 7¾ | 3.809 |
| 2½ | 3.608 | 6 | 3.609 | 9½ | 3.6175 | 13 | 3.6350 | 8¼ | 3.809 |
| 3 | 3.6075 | 6½ | 3.6100 | 10 | 3.6195 | 13½ | 3.6380 | 8¾ | 3.809 |
| 3½ | 3.6075 | 7 | 3.6105 | 10½ | 3.6225 | 14 | 3.6390 | 9¼ | 3.8095 |

*Star-gauging of 3.6-inch B. L. field mortar (steel), No. 1, Watervliet Arsenal, at Sandy Hook, N. J., January 30, 1891.*

| Inches from muzzle. | After round 378, lands. | Inches from muzzle. | After round 378, lands. | Inches from muzzle. | After round 378, lands. | Inches from breech. | After round 378, chamber. |
|---|---|---|---|---|---|---|---|
| ½ | 3.610 | 5 | 3.6085 | 9½ | 3.617 | 6¼ | 3.809 |
| 1 | 3.609 | 5½ | 3.609 | 10 | 3.619 | 7¾ | 3.809 |
| 1½ | 3.6085 | 6 | 3.6095 | 10½ | 3.621 | 9¼ | 3.810 |
| 2 | 3.608 | 6½ | 3.610 | 11 | 3.624 | | |
| 2½ | 3.608 | 7 | 3.610 | 11½ | 3.627 | | |
| 3 | 3.608 | 7½ | 3.611 | 12 | 3.629 | | |
| 3½ | 3.608 | 8 | 3.612 | 12½ | 3.632 | | |
| 4 | 3.6085 | 8½ | 3.613 | 13 | 3.635 | | |
| 4½ | 3.6085 | 9 | 3.614 | 13½ | 3.638 | | |

*Star-gauging of 3.6-inch B. L. field mortar (steel), No. 1, Watervliet Arsenal, at Sandy Hook, N. J., February 13, 1891.*

| Inches from muzzle. | After round 488, lands. | Inches from muzzle. | After round 488, lands. | Inches from muzzle. | After round 488, lands. | Inches from muzzle. | After round 488, chamber. |
|---|---|---|---|---|---|---|---|
| ½ | 3.611 | 5 | 3.610 | 9½ | 3.6185 | 6¼ | 3.809 |
| 1 | 3.610 | 5½ | 3.6105 | 10 | 3.621 | 7¾ | 3.809 |
| 1½ | 3.610 | 6 | 3.611 | 10½ | 3.624 | 9¼ | 3.810 |
| 2 | 3.610 | 6½ | 3.611 | 11 | 3.627 | | |
| 2½ | 3.609 | 7 | 3.612 | 11½ | 3.629 | | |
| 3 | 3.610 | 7½ | 3.612 | 12 | 3.6305 | | |
| 3½ | 3.609 | 8 | 3.613 | 12½ | 3.633 | | |
| 4 | 3.610 | 8½ | 3.614 | 13 | 3.636 | | |
| 4½ | 3.610 | 9 | 3.617 | 13½ | 3.639 | | |

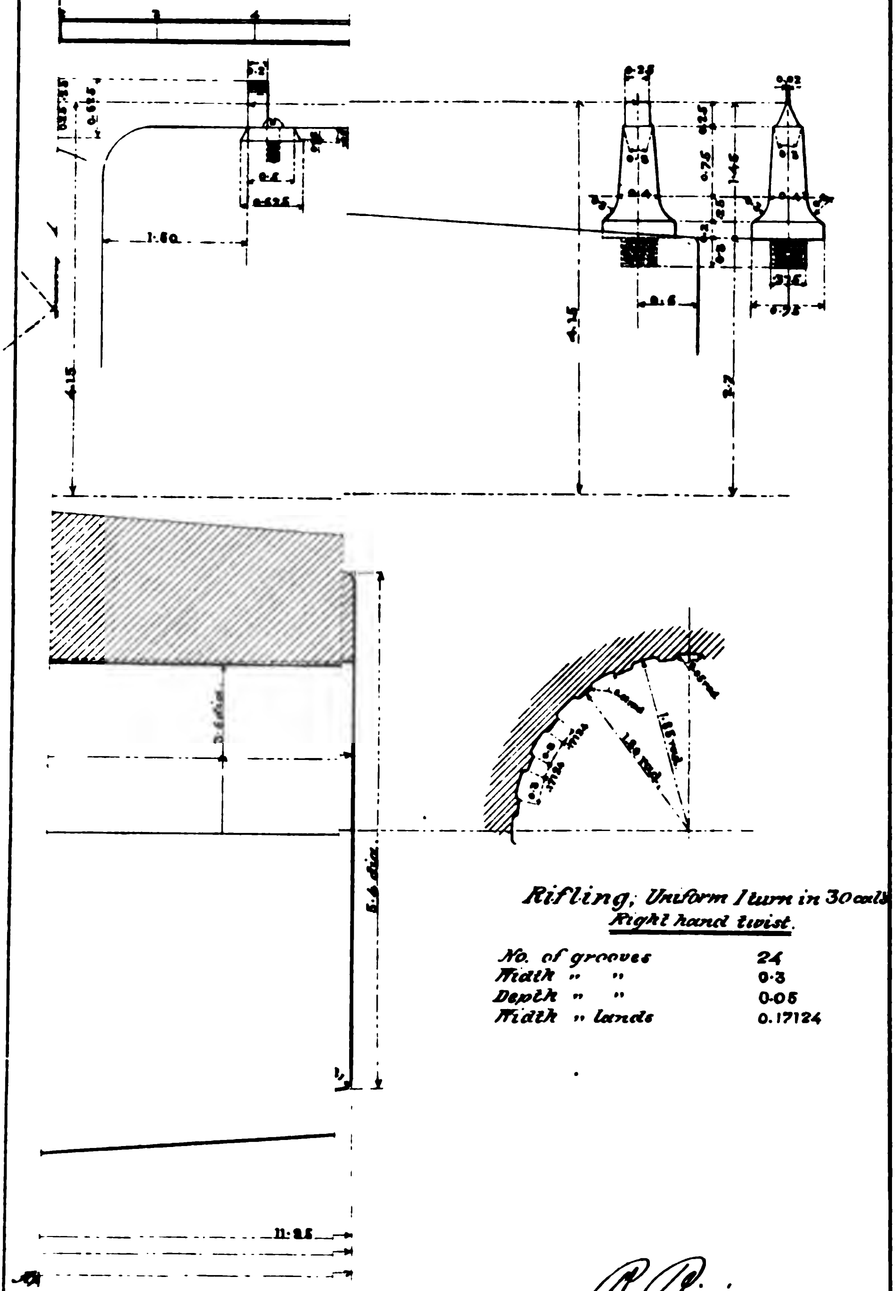
*Star-gauging of 3.6-inch B. L. field mortar (steel), No. 1, Watervliet Arsenal, at Sandy Hook, N. J., February 18, 1891.*

| Inches from muzzle. | After round 594, lands. | Inches from muzzle. | After round 594, lands. | Inches from muzzle. | After round 594, lands. | Inches from breech. | After round 594, chamber. |
|---|---|---|---|---|---|---|---|
| ½ | 3.613 | 5 | 3.612 | 9½ | 3.619 | 6¼ | 3.81 |
| 1 | 3.612 | 5½ | 3.6115 | 10 | 3.621 | 7¾ | 3.81 |
| 1½ | 3.6115 | 6 | 3.6125 | 10½ | 3.624 | 9¼ | 3.8105 |
| 2 | 3.6115 | 6½ | 3.613 | 11 | 3.627 | | |
| 2½ | 3.611 | 7 | 3.613 | 11½ | 3.6285 | | |
| 3 | 3.611 | 7½ | 3.614 | 12 | 3.631 | | |
| 3½ | 3.611 | 8 | 3.614 | 12½ | 3.633 | | |
| 4 | 3.611 | 8½ | 3.6155 | 13 | 3.637 | | |
| 4½ | 3.611 | 9 | 3.617 | 13½ | 3.639 | | |

*Star-gauging of 3.6-inch B. L. mortar (steel), No. 1, Watervliet Arsenal, at Sandy Hook, N. J., February 24, 1891.*

| Inches from muzzle. | After round 694, lands. | Inches from muzzle. | After round 694, lands. | Inches from muzzle. | After round 694, lands. | Inches from breech. | After round 694, chamber. |
|---|---|---|---|---|---|---|---|
| ½ | 3.616 | 5 | 3.6145 | 9½ | 3.623 | 6¼ | 3.811 |
| 1 | 3.615 | 5½ | 3.615 | 10 | 3.624 | 7¾ | 3.811 |
| 1½ | 3.615 | 6 | 3.6155 | 10½ | 3.627 | 9¼ | 3.812 |
| 2 | 3.615 | 6½ | 3.616 | 11 | 3.6295 | | |
| 2½ | 3.615 | 7 | 3.616 | 11½ | 3.6315 | | |
| 3 | 3.6145 | 7½ | 3.6165 | 12 | 3.6335 | | |
| 3½ | 3.6145 | 8 | 3.617 | 12½ | 3.636 | | |
| 4 | 3.6145 | 8½ | 3.618 | 13 | 3.6385 | | |
| 4½ | 3.6145 | 9 | 3.620 | 13½ | 3.6405 | | |

# MORTAR, S



*Rifling; Uniform 1 turn in 30 cals*
*Right hand twist.*

| | |
|---|---|
| *No. of grooves* | 24 |
| *Width " "* | 0·3 |
| *Depth " "* | 0·05 |
| *Width " lands* | 0.17124 |

R. Birnie
*Captain Ordnance Dep't.*

*Record of firing with 3.6-inch B. L. field mortar (steel).* No.

[Object of firing, to te

| Date. | | No. of fire. | Powder. Kind. | Powder. Wgt. | Projectile. Kind. | Projectile. Wgt. | Including sand. | | Elevation. | | Recoil. | Wind, strength and direction. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1891. | | | | *Lbs.* | | *Lbs.* | *Lbs.* | *Oz.* | ° | ' | *Feet.* | |
| Feb. 24 | A. M. ....... | 595 | Lot 7. Density, 1.725. Granulation, 2,500. | 1 | Shell (banded), experimental. Lot 249. | 20 | 1 | 0 | 0 | 00 | ........ | From right and front, 9 miles an hour. |
| | | 596 | | 1 | | 20 | | 14 | 0 | 00 | ........ | |
| | | 597 | | 1 | | 20 | | 13 | 0 | 00 | 9 | |
| | | 598 | | 1 | | 20 | | 14 | 0 | 00 | 9 | |
| | | 599 | Lot 12. Density, 1.725. Granulation, 2,510. | 1 | | 20 | | 15 | 0 | 00 | 9 | |
| | | 600 | | 1 | | 20 | | 13 | 0 | 00 | 9 | |
| | | 601 | | 1 | | 20 | | 15 | 0 | 00 | 9 | |
| | | 602 | | 1 | | 20 | | 14 | 0 | 00 | 9 | |
| | | 603 | Du Pont's I. K. H. Lot 9. Density, 1.725. Granulation, 2,532. | 1 | | 20 | | 15 | 0 | 00 | 9 | |
| | | 604 | | 1 | | 20 | | 14 | 0 | 00 | 9 | |
| | | 605 | | 1 | | 20 | | 13 | 0 | 00 | 9 | |
| | | 606 | | 1 | | 20 | | 14 | 0 | 00 | 9 | |
| | | 607 | | 1 | | 20 | | 15 | 0 | 00 | 9 | |
| | | 608 | | 1 | | 20 | | 15 | 0 | 00 | 9 | |
| | | 609 | | 1 | | 20 | | 14 | 0 | 00 | 9 | |
| | | 610 | | 1 | | 20 | | 14 | 0 | 00 | 9 | |
| | | 611 | | 1 | | 20 | | 14 | 0 | 00 | 9 | |
| | | 612 | | 1 | | 20 | | 12 | 0 | 00 | 9 | |
| | | 613 | | 1 | | 20 | | 11 | 0 | 00 | 9 | |
| | | 614 | | 1 | | 20 | | 11 | 0 | 00 | 9 | |
| | | 615 | | 1 | | 20 | | 15 | 0 | 00 | 9 | |
| | | 616 | | 1 | | 20 | | 14 | 0 | 00 | 9 | |
| | | 617 | | 1 | | 20 | | 15 | 0 | 00 | 9 | |
| | | 618 | | 1 | | 20 | | 13 | 0 | 00 | 9 | |
| | | 619 | | 1 | | 20 | | 15 | 0 | 00 | 9 | |
| | | 620 | | 1 | | 20 | | 15 | 0 | 00 | 9 | |
| | | 621 | | 1 | | 20 | | 15 | 0 | 00 | 9 | |
| | | 622 | | 1 | | 20 | | 16 | 0 | 00 | 9 | |
| | | 623 | | 1 | | 20 | | 15 | 0 | 00 | 9 | |
| | | 624 | | 1 | | 20 | | 14 | 0 | 00 | 9 | |
| | | 625 | | 1 | | 20 | | 15 | 0 | 00 | 9 | |
| | | 626 | | 1 | | 20 | | 10 | 0 | 00 | 9 | |
| | | 627 | | 1 | | 20 | | 14 | 0 | 00 | 9 | |
| | | 628 | | 1 | | 20 | | 11 | 0 | 00 | 9 | |
| | | 629 | | 1 | | 20 | | 10 | 0 | 00 | 9 | |
| | | 630 | | 1 | | 20 | | 15 | 0 | 00 | 9 | |
| | | 631 | | 1 | | 20 | | 11 | 0 | 00 | 9 | |
| | | 632 | | 1 | | 20 | | 14 | 0 | 00 | 9 | |
| | | 633 | | 1 | | 20 | | 14 | 0 | 00 | 9 | |
| | | 634 | | 1 | | 20 | | 14 | 0 | 00 | 9 | |
| | | 635 | Du Pont's I. K. H. Lot 10. Density, 1.725. Granulation, 2,536. | 1 | | 20 | | 11 | 0 | 00 | 9 | |
| | | 636 | | 1 | | 20 | | 12 | 0 | 00 | 9 | |
| | | 637 | | 1 | | 20 | | 14 | 0 | 00 | 9 | |
| | | 638 | | 1 | | 20 | | 11 | 0 | 00 | 9 | |
| | | 639 | | 1 | | 20 | | 15 | 0 | 00 | 9 | |
| | | 640 | | 1 | | 20 | | 12 | 0 | 00 | 9 | |
| | | 641 | | 1 | | 20 | | 13 | 0 | 00 | 9 | |
| | | 642 | | 1 | | 20 | | 13 | 0 | 00 | 9 | |
| | | 643 | | 1 | | 20 | | 12 | 0 | 00 | 9 | |
| | | 644 | | 1 | | 20 | | 15 | 0 | 00 | 9 | |
| | | 645 | | 1 | | 20 | | 13 | 0 | 00 | 9 | |
| | | 646 | | 1 | | 20 | | 14 | 0 | 00 | 9 | |
| | | 647 | | 1 | | 20 | | 13 | 0 | 00 | 9 | |
| | | 648 | | 1 | | 20 | | 13 | 0 | 00 | 9 | |
| | | 649 | | 1 | | 20 | | 14 | 0 | 00 | 9 | |
| | | 650 | | 1 | | 20 | | 14 | 0 | 00 | 9 | |
| | | 651 | | 1 | | 20 | | 14 | 0 | 00 | 9 | |
| | | 652 | | 1 | | 20 | | 13 | 0 | 00 | 9 | |
| | | 653 | | 1 | | 20 | | 14 | 0 | 00 | 9 | |
| | | 654 | | 1 | | 20 | | 13 | 0 | 00 | 9 | |
| | | 655 | | 1 | | 20 | 1 | 1 | 0 | 00 | 9 | |
| | | 656 | | 1 | | 20 | | 15 | 0 | 00 | 9 | |
| | | 657 | | 1 | | 20 | | 13 | 0 | 00 | 9 | |
| | | 658 | | 1 | | 20 | | 14 | 0 | 00 | 9 | |
| | | 659 | | 1 | | 20 | | 15 | 0 | 00 | 9 | |
| | | 660 | | 1 | | 20 | | 14 | 0 | 00 | 9 | |
| | | 661 | | 1 | | 20 | | 13 | 0 | 00 | 9 | |
| | | 662 | | 1 | | 20 | | 15 | 0 | 00 | 9 | |
| | | 663 | | 1 | | 20 | | 15 | 0 | 00 | 9 | |
| | | 664 | | 1 | | 20 | | 13 | 0 | 00 | 9 | |
| | | 665 | | 1 | | 20 | | 15 | 0 | 00 | 9 | |

*Watervliet Arsenal, at Sandy Hook, N. J., February 24, 1891.*

**mortar for endurance.]**

| | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|
| **Mortar mounted on new experimental steel carriage made at Watervliet Arsenal. Cannon friction primers, model of 1887.** | |
| | **Mortar turned over on left side.**<br>**Mortar recoiled off platform.** |
| **Mortar carriage standing on platform of 3-inch spruce plank, 15 feet long, and inclined upward to the rear at an angle of 11 degrees.**<br>**Fired into field butt, section 2.**<br>**Recoil restrained by 2½-inch rope, arranged as in previous firing. Rope allowed recoil of 9 feet.**<br>**Powder loose in chamber.** | |
| | **Breech and block wiped and oiled.** |
| | **Breech and block wiped and oiled.** |

*Record of firing with 3.6-inch B. L. field mortar (steel), No. 1, Watervl*

[Object of firing, to test

| Date. | | No. of fire. | Powder. | | Projectile. | | Including sand. | | Elevation. | | Recoil. | Wind, strength and direction |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Kind. | Wgt. | Kind. | Wgt. | | | | | | |
| 1891. | | | | *Lbs.* | | *Lbs.* | *Lbs.* | *Oz.* | ° | ' | *Feet.* | |
| Feb. 24 | A. M | 666 | Du Pont's I. K. H. Lot 8. Density, 1.725. Granulation, 2,630. | 1 | Shell (banded), experimental. Lot 249. | 20 | | 14 | 0 | 00 | 9 | From right and front, 0 miles an hour. |
| | | 667 | | 1 | | 20 | | 11 | 0 | 00 | 9 | |
| | | 668 | | 1 | | 20 | | 11 | 0 | 00 | 9 | |
| | | 669 | | 1 | | 20 | | 14 | 0 | 00 | 9 | |
| | | 670 | | 1 | | 20 | | 13 | 0 | 00 | 9 | |
| | | 671 | | 1 | | 20 | | 14 | 0 | 00 | 9 | |
| | | 672 | | 1 | | 20 | | 16 | 0 | 00 | 9 | |
| | | 673 | | 1 | | 20 | | 13 | 0 | 00 | 9 | |
| | | 674 | | 1 | | 20 | | 15 | 0 | 00 | 9 | |
| | | 675 | | 1 | | 20 | | 15 | 0 | 00 | 9 | |
| | | 676 | | 1 | | 20 | 1 | 1 | 0 | 00 | 9 | |
| | | 677 | | 1 | | 20 | | 14 | 0 | 00 | 9 | |
| | | 678 | | 1 | | 20 | | 13 | 0 | 00 | 9 | |
| | | 679 | | 1 | | 20 | | 14 | 0 | 00 | 9 | |
| | | 680 | | 1 | | 20 | | 15 | 0 | 00 | 9 | |
| | | 681 | | 1 | | 20 | | 11 | 0 | 00 | 9 | |
| | | 682 | | 1 | | 20 | | 14 | 0 | 00 | 9 | |
| | | 683 | DuPont's I. K. H. Lot 11. Density, 1.725. Granulation, 2,459. | 1 | | 20 | | 15 | 0 | 00 | 9 | |
| | | 684 | | 1 | | 20 | | 15 | 0 | 00 | 9 | |
| | | 685 | | 1 | | 20 | | 14 | 0 | 00 | 9 | |
| | | 686 | | 1 | | 20 | | 14 | 0 | 00 | 9 | |
| | | 687 | | 1 | | 20 | | 15 | 0 | 00 | 9 | |
| | | 688 | | 1 | | 20 | | 13 | 0 | 00 | 9 | |
| | | 689 | | 1 | | 20 | 1 | 0 | 0 | 00 | 9 | |
| | | 690 | | 1 | | 20 | | 15 | 0 | 00 | 9 | |
| | | 691 | | 1 | | 20 | | 14 | 0 | 00 | 9 | |
| | | 692 | | 1 | | 20 | | 13 | 0 | 00 | 9 | |
| | | 693 | | 1 | | 20 | | 13 | 0 | 00 | 9 | |
| | | 694 | | 1 | | 20 | | 12 | 0 | 00 | 9 | |
| Feb. 24 | P. M | 695 | | 1 | | 20 | | 14 | 0 | 00 | 10 | |
| | | 696 | | 1 | | 20 | | 14 | 0 | 00 | 10 | |
| | | 697 | | 1 | | 20 | | 14 | 0 | 00 | 10 | |
| | | 698 | | 1 | | 20 | 1 | 0 | 0 | 00 | 10 | |
| | | 699 | | 1 | | 20 | | 15 | 0 | 00 | 10 | |
| | | 700 | | 1 | | 20 | | 14 | 0 | 00 | 10 | |
| | | 701 | | 1 | | 20 | | 14 | 0 | 00 | 10 | |
| | | 702 | | 1 | | 20 | | 11 | 0 | 00 | 10 | |
| | | 703 | | 1 | | 20 | | 11 | 0 | 00 | 10 | |
| | | 704 | | 1 | | 20 | | 13 | 0 | 00 | 10 | |
| | | 705 | | 1 | | 20 | | 12 | 0 | 00 | 10 | |
| | | 706 | | 1 | | 20 | | 12 | 0 | 00 | 10 | |
| | | 707 | | 1 | | 20 | | 14 | 0 | 00 | 10 | |
| | | 708 | | 1 | | 20 | | 14 | 0 | 00 | 10 | |
| | | 709 | | 1 | | 20 | | 15 | 0 | 00 | 10 | |
| | | 710 | | 1 | | 20 | | 14 | 0 | 00 | 10 | |
| | | 711 | | 1 | | 20 | | 14 | 0 | 00 | 10 | |
| | | 712 | | 1 | | 20 | | 13 | 0 | 00 | 10 | |
| | | 713 | | 1 | | 20 | | 14 | 0 | 00 | 10 | |
| | | 714 | | 1 | | 20 | | 14 | 0 | 00 | 10 | |

A. MORDECAI.
*Colonel Ordnance Department, U. S. A., President of the Board.*

*Arsenal, at Sandy Hook, N. J., February 24, 1891*—Continued.

mortar for endurance.]

| | Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data. |
|---|---|
| Mortar mounted on new experimental steel carriage made at Watervliet Arsenal. Cannon friction primers, model of 1887. | |
| | Vent shield broken off. |
| | Rope allowed recoil of 9 feet. |
| Recoil restrained by 2½-inch rope, arranged as in previous firing.<br>Fired into field butt, section 2.<br>Powder loose in chamber.<br>Elevation of piece increased by shock of discharge at each fire. | |
| | Rope allowed recoil of 10 feet. Five hundredth round with full charge. |
| | Mortar fell forward on face. |
| | Mortar fell forward on face. |
| | Mortar turned over on right side. |
| Condition of mortar after completion of test: Front sight bent and partly unscrewed. Carrying bolts in trunnions partly unscrewed. One lever handle bent. Arc of elevating apparatus worn smooth by clamps. Vent shield broken.<br>Firing conducted by Lieut. O. M. Lissak, O. D., assistant proof officer. Mortar star gauged after round 694, February 24, 1891, by Lieut. O. M. Lissak, O. D. | |

Ormond M. Lissak,
*Lieutenant Ordnance Department, Recorder.*

*Star-gauging of 3.6-inch B. L. field mortar, No. 1, Watervliet Arsenal, at Sandy Hook, N. J., August 12, 1890.*

| Inches from breech. | After 90 rounds, chamber. | Inches from muzzle. | After 90 rounds, lands. | Inches from muzzle. | After 90 rounds, lands. | Inches from muzzle. | After 90 rounds, lands. | Inches from muzzle. | After 90 rounds, lands. |
|---|---|---|---|---|---|---|---|---|---|
| 6¼ | 3.809 | ½ | 3.607 | 4 | 3.606 | 7½ | 3.607 | 11 | 3.623 |
| 6¾ | 3.809 | 1 | 3.607 | 4½ | 3.606 | 8 | 3.608 | 11½ | 3.626 |
| 7¼ | 3.809 | 1½ | 3.607 | 5 | 3.606 | 8½ | 3.610 | 12 | 3.628 |
| 7¾ | 3.809 | 2 | 3.6065 | 5½ | 3.606 | 9 | 3.6115 | 12½ | 3.632 |
| 8¼ | 3.809 | 2½ | 3.606 | 6 | 3.606 | 9½ | 3.6155 | 13 | 3.634 |
| 8¾ | 3.809 | 3 | 3.606 | 6½ | 3.6065 | 10 | 3.618 | 13½ | 3.637 |
| 9¼ | 3.809 | 3½ | 3.606 | 7 | 3.6065 | 10½ | 3.6205 | 14 | 3.638 |

*Star-gauging of 3.6-inch B. L. field mortar (steel), No. 1, Watervliet Arsenal, at Sandy Hook, N. J., November 26, 1890.*

| Inches from muzzle. | After round 222, lands. | Inches from muzzle. | After round 222, lands. | Inches from muzzle. | After round 222, lands. | Inches from muzzle. | After round 222, lands. | Inches from breech. | After round 222, chamber vertical. |
|---|---|---|---|---|---|---|---|---|---|
| ½ | 3.609 | 4 | 3.6075 | 7½ | 3.6110 | 11 | 3.6250 | 6¼ | 3.809 |
| 1 | 3.6085 | 4½ | 3.608 | 8 | 3.6115 | 11½ | 3.6275 | 6¾ | 3.809 |
| 1½ | 3.608 | 5 | 3.6085 | 8½ | 3.6125 | 12 | 3.6300 | 7¼ | 3.809 |
| 2 | 3.608 | 5½ | 3.609 | 9 | 3.6150 | 12½ | 3.6325 | 7¾ | 3.809 |
| 2½ | 3.608 | 6 | 3.609 | 9½ | 3.6175 | 13 | 3.6350 | 8¼ | 3.809 |
| 3 | 3.6075 | 6½ | 3.6100 | 10 | 3.6195 | 13½ | 3.6380 | 8¾ | 3.809 |
| 3½ | 3.6075 | 7 | 3.6105 | 10½ | 3.6225 | 14 | 3.6390 | 9¼ | 3.8095 |

*Star-gauging of 3.6-inch B. L. field mortar (steel), No. 1, Watervliet Arsenal, at Sandy Hook, N. J., January 30, 1891.*

| Inches from muzzle. | After round 378, lands. | Inches from muzzle. | After round 378, lands. | Inches from muzzle. | After round 378, lands. | Inches from breech. | After round 378, chamber. |
|---|---|---|---|---|---|---|---|
| ½ | 3.610 | 5 | 3.6085 | 9½ | 3.617 | 6¼ | 3.809 |
| 1 | 3.609 | 5½ | 3.609 | 10 | 3.619 | 7¼ | 3.809 |
| 1½ | 3.6085 | 6 | 3.6095 | 10½ | 3.621 | 9¼ | 3.810 |
| 2 | 3.608 | 6½ | 3.610 | 11 | 3.624 | | |
| 2½ | 3.608 | 7 | 3.610 | 11½ | 3.627 | | |
| 3 | 3.608 | 7½ | 3.611 | 12 | 3.629 | | |
| 3½ | 3.608 | 8 | 3.612 | 12½ | 3.632 | | |
| 4 | 3.6085 | 8½ | 3.613 | 13 | 3.635 | | |
| 4½ | 3.6085 | 9 | 3.614 | 13½ | 3.638 | | |

*Star-gauging of 3.6-inch B. L. field mortar (steel), No. 1, Watervliet Arsenal, at Sandy Hook, N. J., February 13, 1891.*

| Inches from muzzle. | After round 488, lands. | Inches from muzzle. | After round 488, lands. | Inches from muzzle. | After round 488, lands. | Inches from muzzle. | After round 488, chamber. |
|---|---|---|---|---|---|---|---|
| ½ | 3.611 | 5 | 3.610 | 9½ | 3.6185 | 6¼ | 3.809 |
| 1 | 3.610 | 5½ | 3.6105 | 10 | 3.621 | 7¾ | 3.809 |
| 1½ | 3.610 | 6 | 3.611 | 10½ | 3.624 | 9¼ | 3.810 |
| 2 | 3.610 | 6½ | 3.611 | 11 | 3.627 | | |
| 2½ | 3.609 | 7 | 3.612 | 11½ | 3.629 | | |
| 3 | 3.610 | 7½ | 3.612 | 12 | 3.6305 | | |
| 3½ | 3.609 | 8 | 3.613 | 12½ | 3.633 | | |
| 4 | 3.610 | 8½ | 3.614 | 13 | 3.636 | | |
| 4½ | 3.610 | 9 | 3.617 | 13½ | 3.639 | | |

*Star-gauging of 3.6-inch B. L. field mortar (steel), No. 1, Watervliet Arsenal, at Sandy Hook, N. J., February 18, 1891.*

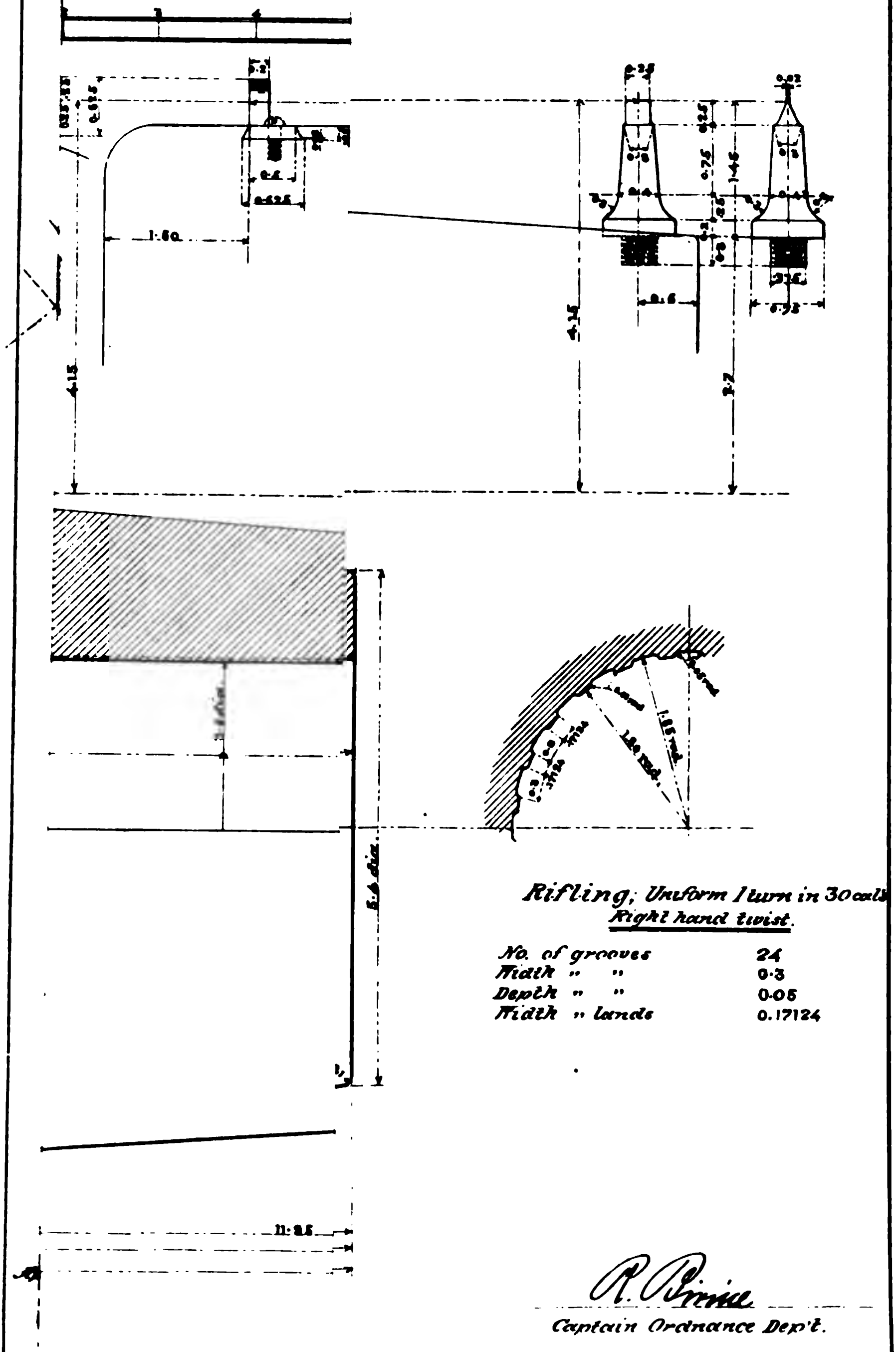
| Inches from muzzle. | After round 594, lands. | Inches from muzzle. | After round 594, lands. | Inches from muzzle. | After round 594, lands. | Inches from breech. | After round 594, chamber. |
|---|---|---|---|---|---|---|---|
| ½ | 3.613 | 5 | 3.612 | 9½ | 3.619 | 6¼ | 3.81 |
| 1 | 3.612 | 5½ | 3.6115 | 10 | 3.621 | 7¾ | 3.81 |
| 1½ | 3.6115 | 6 | 3.6125 | 10½ | 3.624 | 9¼ | 3.8105 |
| 2 | 3.6115 | 6½ | 3.613 | 11 | 3.627 | | |
| 2½ | 3.611 | 7 | 3.613 | 11½ | 3.6285 | | |
| 3 | 3.611 | 7½ | 3.614 | 12 | 3.631 | | |
| 3½ | 3.611 | 8 | 3.614 | 12½ | 3.633 | | |
| 4 | 3.611 | 8½ | 3.6155 | 13 | 3.637 | | |
| 4½ | 3.611 | 9 | 3.617 | 13½ | 3.639 | | |

*Star-gauging of 3.6-inch B. L. mortar (steel), No. 1, Watervliet Arsenal, at Sandy Hook, N. J., February 24, 1891.*

| Inches from muzzle. | After round 694, lands. | Inches from muzzle. | After round 694, lands. | Inches from muzzle. | After round 694, lands. | Inches from breech. | After round 694, chamber. |
|---|---|---|---|---|---|---|---|
| ½ | 3.616 | 5 | 3.6145 | 9½ | 3.623 | 6¼ | 3.811 |
| 1 | 3.615 | 5½ | 3.615 | 10 | 3.624 | 7¾ | 3.811 |
| 1½ | 3.615 | 6 | 3.6155 | 10½ | 3.627 | 9¼ | 3.812 |
| 2 | 3.615 | 6½ | 3.616 | 11 | 3.6295 | | |
| 2½ | 3.615 | 7 | 3.616 | 11½ | 3.6315 | | |
| 3 | 3.6145 | 7½ | 3.6165 | 12 | 3.6335 | | |
| 3½ | 3.6145 | 8 | 3.617 | 12½ | 3.636 | | |
| 4 | 3.6145 | 8½ | 3.618 | 13 | 3.6385 | | |
| 4½ | 3.6145 | 9 | 3.620 | 13½ | 3.6405 | | |

PLATE I.

# MORTAR, S



*Rifling; Uniform 1 turn in 30 cal*
*Right hand twist.*

| | |
|---|---|
| *No. of grooves* | 24 |
| *Width " "* | 0.3 |
| *Depth " "* | 0.05 |
| *Width " lands* | 0.17124 |

R. Birnie
*Captain Ordnance Dep't.*

Appendix 37, 1891.

# APPENDIX 38.

## *ORDNANCE BOARD REPORT NO. 1.—1888.*

(One plate.)

GOVERNOR'S ISLAND, NEW YORK HARBOR,
*January 12, 1888.*

The CHIEF OF ORDNANCE, U. S. ARMY,
*Washington, D. C.:*

SIR: In compliance with ninth indorsement on Ordnance Office file No. 1600 of 1887, the Board has the honor to submit the following report on the test of the Armstrong combination fuse as applied to the Eureka shell referred to in file 1600 A of 1887, fired from an 8-inch M. L. converted rifle.

### DESCRIPTION OF THE FUSE.

The body, A, of this fuse, Plate I, is graduated in inches on the exterior of an enlargement a little above its middle, which contains an open annular groove, B, filled with fuse composition. A partition in the plug affords points of support for two pointed anvils, C and D. Small openings about the base of the former permit the passage of the flame to a radial channel, E, which in turn connects with the groove B, above referred to. A channel, F, in part radial and in part longitudinal, affords communication from the upper portion of the fuse to the interior of the shell.

A brass disk, G, covers the upper portion of the groove B. It has on its interior an annular groove, H, filled with composition and on its lower face a single hole, which affords communication between the two grooves last mentioned.

The face of the disk is covered with a leather washer for packing the joint between the disk and that part of the fuse body adjoining the groove B.

The upper end of the fuse terminates in a screw cap, I, to which a capped plunger or igniter, J, is secured by a small brass wire.

A screw collar, G I, holds the disk G in place and connects the cap I with the body of the fuse. The cap and igniter may be removed for safety in transportation and applied to the fuse when needed.

The parts described constitute the time portion of the combination.

The percussion arrangement constitutes the lower or inner portion as applied to the shell, and consists of a capped plunger, K, with band, L, a hollow cylinder, M, which affords a bearing for the band and thereby serves to hold back the plunger, a guide ring, N, for the outer end of the plunger, which also assists in closing the inner end of the hollow screw cap O, filled with rifle powder. The screw cap closes the inner end of the fuse body. An opening through this cap affords communication with the bursting charge.

This opening is covered with a thin brass disk, P, pressed in a slight counterbore and secured by shellac.

In this fuse the body A and plunger K are of soft metal; all the other parts are of brass or bronze.

### THE SETTING OF THE FUSE.

To set the fuse for any particular time the screw collar G I, at the upper end of the fuse, is loosened and the disk G rotated about its axis until the hole in its lower face lies opposite the number of inches in the graduated scale corresponding to the time desired. This is indicated by an arrow opposite the hole and on the outer edge of the disk. The collar is then screwed firmly down so as to bring the disk in close contact with the graduated portion of the fuse body.

### THE ACTION OF THE FUSE.

The action of the fuse is as follows:

When the piece is fired, the igniter J, by its inertia due to the shock of discharge, breaks the wire by which it is secured to the screw cap I, and impinges on the anvil C. The percussion cap explodes and ignites the composition in the groove B, which, after burning the requisite number of seconds, ignites the composition in the disk through the hole in its face. The flame communicates by the channel F to the rifle powder in the cap O, and thence to the bursting charge.

Should the fuse fail to act on time, as intended, the percussion part of the combination comes into action when the projectile strikes the object.

The inertia of the plunger carries it forward, the band being stripped off by the cylinder M, and causes it to impinge on the anvil D.

The resulting explosion of the percussion cap ignites the charge of rifle powder in the screw cap at the inner end of the fuse, which blows out the thin brass disk covering the opening, and communicates the flame to the bursting charge.

### TESTS OF THE FUSE.

On September 7, 1887, five of the shells provided with this fuse were fired at the 1-mile target.

As the fuse was graduated in inches and the corresponding time in seconds was not known to the Board, the first shots were lost, owing to the elevations being insufficient to afford opportunity for the fuse to burn to the point at which it was set.

On December 8, 1887, eight shells were fired at the mile target, and on December 12, 1887, sixteen more were fired at the 1-mile target, the 3,000-yards target, and at sea. On the day last mentioned, the time igniters were removed from six of the fuses in order to test the sensitiveness of the percussion part of the combination and to be certain that the explosion was due to impact only.

An analysis of the results obtained indicated that there was a very fair degree of uniformity in the times of burning of the various inches for which the fuses were set, except for the first 1 inch or 1.5 inches; also, that as five out of the six fuses from which the igniters had been removed failed to produce explosion of the shell on impact with sand or water, the percussion part of the fuse was not sufficiently sensitive.

In order to verify these results and to be certain that the times were correctly taken, ten more shells were fired January 3, 1888, and the times were taken by two observers.

Eight of these were fired at sea, for time bursts, and two, with igniters removed, down the beach, for impact with the sand. The records for time were much more satisfactory than those obtained at the previous trials, indicating almost absolute uniformity in the time per inch. Both shells fired down the beach failed to explode on impact.

The following table shows the results of all firings to test this fuse:

| Date. | Gun. | Powder weight. | Projectile weight. | Elevation. | Fuse, how set. | Time of bursting. | Remarks. |
|---|---|---|---|---|---|---|---|
| 1887. | | *Pounds.* | *Pounds.* | ° ′ | *Inches.* | *Seconds.* | |
| Sept. 7 | 8-inch muzzle-loading rifle, converted, steel lined, No. 1. | 35 | 156$\frac{3}{16}$ | 3 5 | 4 | 5⅛ | Fired at 1-mile target. Struck 200 yards beyond target and ricochetted out to sea, bursting on striking water. |
| Sept. 7 | | 35 | 156 | 3 5 | 3 | 5 | Fired at 1-mile target. Struck 200 yards beyond target and ricochetted and burst in air. |
| Sept. 7 | | 35 | 157 | 3 5 | 2 | 5 | Fired at 1-mile target. Burst in air. |
| Sept. 7 | | 35 | 156 | 3 5 | 2 | 4¾ | Fired at 1-mile target. Burst in air. |
| Sept. 7 | | 35 | 156 | 3 5 | 1.5 | 5 | Fired at 1-mile target. Burst in air. |
| | | | | | | | The last three shots were observed from the firing ground to burst in air, but were reported by the men at the target to have burst on striking ground. |
| Dec. 8 | | 35 | 157 | 3 5 | 1 | Lost. | Fired at 1-mile target. Burst in air. |
| Dec. 8 | | 35 | 157 | 3 5 | 1 | 1¾ | Fired at 1-mile target. Burst in air. |
| Dec. 8 | | 35 | 157 | 3 5 | 1.5 | 3⅛ | Fired at 1-mile target. Burst in air. |
| Dec. 8 | | 35 | 156 | 3 5 | 1.5 | 3¼ | Fired at 1-mile target. Burst in air. |
| Dec. 8 | | 35 | 154 | 3 5 | 4 | 4¾ | Fired at 1-mile target. Burst on striking ground. |
| Dec. 8 | | 35 | 155 | 3 5 | 4 | 9¼ | Fired at 1-mile target. Struck ground, ricochetted, and burst in air. |
| Dec. 8 | | 35 | 154 | 4 0 | 2 | 4¾ | Fired at 1-mile target. Burst in air. |
| Dec. 8 | | 35 | 156 | 4 0 | 2 | 4¾ | Fired at 1-mile target. Burst in air. |
| Dec. 12 | | 35 | 157 | 3 5 | 1 | 1¾ | Fired at 1-mile target. Burst in air. |
| Dec. 12 | | 35 | 157 | 3 5 | 1 | 1⅝ | Fired at 1-mile target. Burst in air. |
| Dec. 12 | | 35 | 155 | 3 5 | 1 | 1¾ | Fired at 1-mile target. Burst in air. |
| Dec. 12 | | 35 | 155 | 4 30 | 3 | Lost. | Fired at 3,000-yards target. |
| Dec. 12 | | 35 | 155 | 6 0 | 3 | 7⅛ | Fired to sea. Burst in air. |
| Dec. 12 | | 35 | 155 | 6 0 | 3 | 6¾ | Fired to sea. Burst in air. |
| Dec. 12 | | 35 | 157 | 6 0 | 3 | 7¼ | Fired to sea. Burst in air. |
| Dec. 12 | | 35 | 156 | 4 0 | Igniter removed. | ........ | Fired to sea. Struck in 6¼ seconds, ricochetted, and did not burst. |
| Dec. 12 | | 35 | 157 | 3 5 | Igniter removed. | ........ | Fired at 1-mile target. Burst on striking ground. |
| Dec. 12 | | 35 | 155 | 3 5 | Igniter removed. | ........ | Fired at 1-mile target. Struck ground, ricochetted, and did not burst. |

| Date. | Gun. | Powder weight. | Projectile weight. | Elevation. | Fuse, how set. | Time of bursting. | Remarks. |
|---|---|---|---|---|---|---|---|
| 1887. | | *Pounds.* | *Pounds.* | ° ′ | | *Seconds.* | |
| Dec. 12 | 8-inch muzzle-loading rifle, converted, steel lined, No. 1. | 35 | 157 | 3 5 | Igniter removed. | ........ | Fired at 1-mile targ Struck ground. re chetted, and did burst. |
| Dec. 12 | | 35 | 157 | 2 0 | Igniter removed. | ........ | Fired to sea. Stru water, ricochetted, a did not burst. |
| Dec. 12 | | 35 | 155 | 2 0 | Igniter removed. | ........ | Fired to sea. Did no burst. |
| Dec. 12 | | 35 | 157 | 8 0 | 5 | Lost. | Fired to sea. Broke in or near gun. |
| Dec. 12 | | 35 | 157 | 8 0 | 5 | Lost. | Fired to sea. Struck water in 10¼ second and did not burst. |
| Dec. 12 | | 35 | 156 | 12 0 | 5 | 12½ | Fired to sea. Burst air. |
| 1888. | | | | | | | |
| Jan. 3 | | 35 | 156$\frac{9}{16}$ | 12 0 | 5 | 12½ | Fired to sea. Burst air. |
| Jan. 3 | | 35 | 156$\frac{9}{16}$ | 12 0 | 5 | 12½ | Fired to sea. Burst air. |
| Jan. 3 | | 35 | 156$\frac{9}{16}$ | 12 0 | 4 | 10 | Fired to sea. Burst air. |
| Jan. 3 | | 35 | 156$\frac{9}{16}$ | 12 0 | 4 | 10 | Fired to sea. Burst air. |
| Jan. 3 | | 35 | 156$\frac{9}{16}$ | 12 0 | 3.5 | 8¾ | Fired to sea. Burst air. |
| Jan. 3 | | 35 | 156$\frac{9}{16}$ | 12 0 | 3.5 | 8¾ | Fired to sea. Burst air. |
| Jan. 3 | | 35 | 157$\frac{8}{16}$ | 1 30 | Igniter removed. | ........ | Fired down beach. Did not burst. |
| Jan. 3 | | 35 | 158$\frac{9}{16}$ | 1 30 | Igniter removed. | ........ | Fired down beach. D not burst. |
| Jan. 3 | | 35 | 158$\frac{9}{16}$ | 12 0 | 1 | 2½ | Fired to sea. Burst air. |
| Jan. 3 | | 35 | 158$\frac{9}{16}$ | 12 0 | 1 | 2½ | Fired to sea. Burs air. |

Taking a mean of all times observed, there results the following the various inches for which the fuses were set:

| Inches for which set. | Time of bursting. | Average time per inch. |
|---|---|---|
| | *Seconds.* | *Seconds.* |
| 1 | 1.98 | 1.98 |
| 1.5 | 3.19 | 2.13 |
| 2 | 4.81 | 2.40 |
| 3 | 7.17 | 2.39 |
| 3.5 | 8.75 | 2.50 |
| 4 | 9.75 | 2.44 |
| 5 | 12.5 | 2.50 |

For the last day's firing the record is as follows:

| Inches for which set. | Time of bursting. | Average time per inch. |
|---|---|---|
| | *Seconds.* | *Seconds.* |
| 1 | 2.5 | 2.5 |
| 3.5 | 8.75 | 2.5 |
| 4 | 10 | 2.5 |
| 5 | 12.5 | 2.5 |

### CONCLUSION.

After careful consideration of the above results, the Board is of the opinion that, as a time fuse, the Armstrong is exceedingly satisfactory, but as a percussion fuse it is not sufficiently sensitive to justify its reproduction without modification for shrapnel for field guns. Its lack of sensitiveness is probably due to the lightness of the plunger and to the work necessary to force the guard band over the shoulder against which it bears.

A desirable feature in the construction of this fuse is that which admits of the cap and time igniter being applied to it at the last moment; that is, in the case of muzzle-loaders after the projectile and fuse have been placed in the bore. This adds to the safety of the men during the operation of loading, though it by no means eliminates all danger, since the percussion plunger must be in the fuse before the latter is applied to the projectile. It also adds to the safety of the fuse during handling and transportation, but the principle, if possible, should be extended to the percussion plunger as well.

In the Gill combination fuse, recommended for trial by indorsement of January 11, 1888, on Ordnance Office file No. 1,593 of 1886, the construction of the two plungers is absolutely the same, and as much danger is to be apprehended from one of them as from the other. An arrangement, similar to that in the Armstrong, by which both could be readily removed without the aid of a screw-driver and which will enable caps and plungers to be held together, is thought to be desirable.

A. MORDECAI,
*Lieut. Col., Ord. Dept., U. S. A., Pres't of the Board.*
J. P. FARLEY,
*Major, Ordnance Department, U. S. Army.*
JOHN E. GREER,
*Captain, Ordnance Department, U. S. Army.*

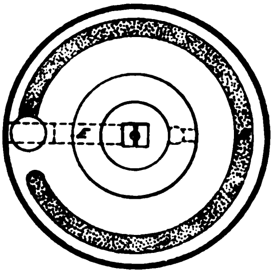
(259–'88.)

PLATE

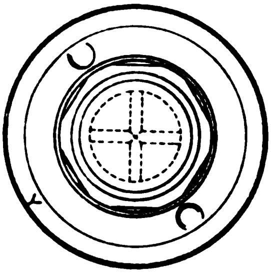
# ARMSTRONG'S COMBINATION FUZE

SCALE OF INCHES

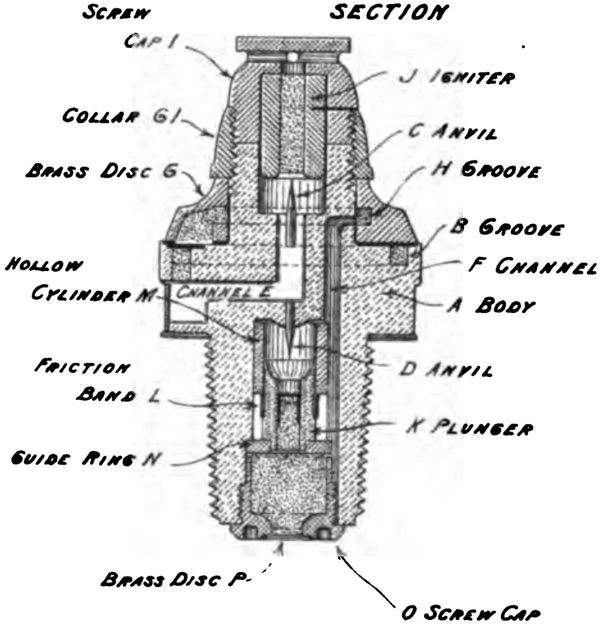
PLAN OF BODY.



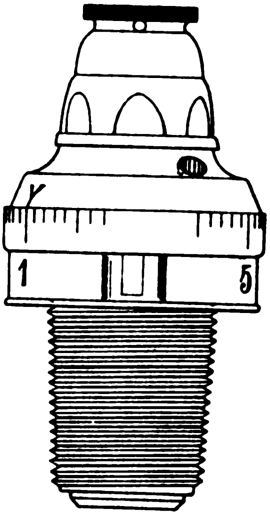
TOP VIEW.



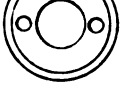
SECTION



EXTERIOR



PLAN OF SCREW CAP



A Mordecai

LIEUT. COLONEL OF ORDNANCE
PRESIDENT OF BOARD.

ORDNANCE BOARD U.S.A.
GOVERNORS ISLAND JAN. 12TH 1888.

Ord 52 1

Appendix 38,189

# APPENDIX 39.

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## *SMOKELESS POWDERS—FRENCH AND GERMAN—FIRING RESULTS, ETC.*

(One plate.)

### SMOKELESS POWDER, $^C/_{89}$.

[Translation.—Berlin Post, September 30, 1890, No. 268.]

### THE CAST STEEL MANUFACTORY OF FRIED.

Krupp, in Essen, has put at our disposal a short report, which gives very valuable disclosures as to the nature and characteristics of the smokeless cannon and musket powder which has formed the subject of experiments for one and one-quarter years. The results in velocity and pressure measurements obtained at the Krupp cannon factory in experiments with smokeless cannon powder, $^C/_{89}$, have already been published by us (in No. 116), so far as they were previously known, and we attempted to draw conclusions therefrom, which, of course, were not exhaustive or free from objection. The present report forms as it were the elucidation of those results, and is, at the same time, the first authentic statement upon this matter. Hence we take this opportunity to communicate the contents of the report as fully as possible.

The failure of the old experiments to establish a new composition in place of the powder formed by a mixture of saltpeter, sulphur, and charcoal is attributed to the excessive gas pressure of the nitrated substance used, which destroyed the weapons.

Capt. Schultze, of the Prussian artillery, with his nitrated wood fiber, Uchatius, of Austria, with his nitrated starch, and Lenk, with his gun cotton, are taken as representatives of the old endeavors, which extended over thirty years. Only in the last few years has success been had in avoiding the old difficulties, although the method of so doing has been known for a long time.

Nitrated cotton is the basis of all new kinds of powder. This nitrated cotton, according to the strength of the acid used and according to the method, appears in three forms, viz: as (1) trinitro-cellulose, (2) binitro-cellulose, (3) mononitro-cellulose. All three are nitrogen compounds, the other elements being carbon, hydrogen, and oxygen. Compound 3 has the highest proportion of carbon and the lowest of nitrogen; it is the nearest of the three to cellulose, which contains no nitrogen. Compound 1 has the lowest proportion of carbon and the highest of nitrogen. Compound 2 stands between the other two. By treatment with acid, compound 1 retains the least hydrogen and takes up the most oxygen, etc. No one of these compounds has ever been obtained entirely free from the others. They are always more or less is predominant we have gun cotton. When (2) binitro-cellulose predominates we have collodion cotton [Kollodium wolle. Tech. Dict. gives "soluble pyroxiline for preparation of collodion."—T. A. B.]. The former is soluble in acetic ether; the latter in alcoholic (Weingeist) ether and in nitro-glycerine.

The well-known inventor of dynamite, Mr. Alfred Nobel, of Stockholm, who, in 1863, succeeded in producing nitro-glycerine in large quantities, used for a number of years to utilize the solubility of collodion cotton in nitro-glycerine to produce a superior explosive, viz, blasting gelatine. This blasting gelatine is a honey-like or rubber-like mass, of the color of glue, consisting of 5 to 7 parts of collodion cotton dissolved in 95 to 93 parts of nitro-glycerine. In a similar way Nobel succeeded in producing a firing powder by dissolving collodion cotton in like parts of nitro-glycerine. The production took place in the following manner: Under a temperature of 6° to 8° C., one part of collodion cotton was added to 6 to 8 parts of nitro-glycerine. The whole took place in a chamber from which the air could be exhausted by means of an air pump, so that the nitro-glycerine should be brought into close connection with the cotton. Then, in a press or by means of a centrifugal pump, such proportion of nitro-glycerine is removed as is necessary for the proposed combination proportions. The cake coming from the press or pump is then cut to pieces and brought to a temperature of 60° or 90° C., when the nitro-glycerine dissolves the cotton. The mass is then rolled out in thin sheets, being always kept at the same high temperature. These thin sheets are then pressed together under the roll in thicker sheets, still at the same temperature. The product thus kept in the form of sheets must be perfectly homogeneous and uniformly translucent in all places. The thickness of the sheets is regulated by the size of grain of the powder required. The powder comes out in the form of cubes or sheets. To secure chemical permanence, 1 to 2 per cent of diphenylamine can be added at the very beginning to the nitro-glycerine. This is a form of aniline which is designated in chemistry as phenylamine. The foregoing process is taken from German patent No. 51,471.

Older processes, as given by other publications, included the use of camphor or benzole, which were the cause of failure.

The high temperatures necessary in the present process involve no danger, as nitro-glycerine is known to explode only when heated to 180° C.—T. A. B.

The first trials of cannon powder $^{C}/_{89}$ submitted by Mr. Nobel to the Krupp factory gave very favorable results. Their continuation on a large scale further confirms the good qualities of the powder. The experiments were gradually extended up to the 30.5 cm. caliber cannon.

According to the report the important artillery qualities of the new powder are as follows:

(1) The new powder is, on an average, three times as powerful as the old. Hence for the same projectile velocity only one-third as much of the new powder is used as of the old.

(2) The new powder gives the same projectile velocity as the old, with essentially less gas pressure. Hence it is possible to increase the velocity of the projectile very materially.

(3) The recoil of the cannon, due to the new powder, is essentially less, for the same projectile velocity, than it is with the old. Hence an increase in projectile initial velocity is permissible without the carriage being thereby more strained than formerly.

The results of velocity and pressure measurements in experiments with smokeless powder, $^{C}/_{89}$ (given in No. 116), included the above statements 1 and 2.

Of the examples contained in the report prominence should be given to the following:

| Gun. | Weight of projectile. | Coarse-grained powder. | | | Prismatic powder, $^{C}/_{82}$. | | | New powder, $^{C}/_{89}$. | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Charge. | Velocity. | Pressure. | Charge. | Velocity. | Pressure. | Charge. | Velocity. | Pressure. |
| Field: | *Kilos.* | *Kilos.* | *Meters* | *Atm.* | *Kilos.* | *Meters* | *Atm.* | *Kilos.* | *Meters* | *Atm.* |
| 7.5 cm | 4.03 | 1 | 465 | 1,800 | ...... | ...... | ...... | 0.35 | 485 | 1,295 |
| 8.7 cm | 6.08 | 1.05 | 460 | 2,000 | ...... | ...... | ...... | 0.50 | 463 | 1,475 |
| Ship and coast cannon, $^{L}/_{35}$, 21 cm | 140 | ...... | ...... | ...... | 56 | 577 | 2,330 | 20.00 | 583 | 1,950 |

As regards increase in projectile velocity, we take the results given in the following table:

| | Initial velocity. | Pressure. |
|---|---|---|
| | *Meters.* | *Atm.* |
| 5 cm. cannon $^{L}/_{40}$ | 674 | 2,040 |
| 8 cm. $^{L}/_{40}$ | 719 | 1,775 |
| | 746 | 2,100 |
| 12 cm. quick fire $^{L}/_{35}$ | 696 | 2,170 |
| 15 cm. $^{L}/_{35}$ | 717 | 2,500 |
| | 735 | 2,605 |
| 21 cm. $^{L}/_{35}$ | 680 | 2,360 |
| | 710 | 2,235 |

As regards the chemical combination of the new powder, it has already been stated that it consists of like parts of nitro-glycerine and collodion cotton. A chemical reaction between the two constituents does not, however, take place. Each, regarded by itself, appears to be a nitro-compound; the nitro-glycerine as a trinitro; the collodion cotton as a binitro. This designation is in conformity with the equivalent value of the peroxide of nitrogen (untersaltpeter säure), which itself consists of 1 equivalent of nitrogen and 2 equivalents of oxygen. The base of each of the two compounds consists of carbon, hydrogen, and oxygen in different equivalents. While the molecular weight of nitro-glycerine is 227 and that of collodion cotton 252, the molecular weight of the new powder is calculated at 4,538. The products of reaction are given as carbonic-oxide gas, carbonic acid, aqueous vapor, and nitrogen (in a free state). The chemical formula of the new powder is $10\,C_3\,H_5\,(ONO_2)_3+9\,C_6\,H_7\,O_2\,O\,H\,(O\,N\,O_2)_2=58CO+26CO_2+61H_2O+N$. The formula in front of the first + sign is that of nitro-glycerine; the one after it that of collodion cotton.

As is evident, the products are solely gaseous. The small, faint quantity of ash from the collodion cotton can be disregarded. Of the products of combustion named, only the aqueous vapor is visible after it has condensed. The nitrogen is visible only in case it enters into combination with the oxygen of the atmosphere, which is regarded as probable. Hence, what is visible in firing is powder *vapor*, not powder smoke. The powder is therefore truly *smokeless*, and we have here, at small charges, *e. g.*, the musket, the quantity of vapor is extremely small and instantly disappears. In cannon, with their larger charges, it is correspondingly greater, but it is also quickly dissipated, as eyewitnesses can testify. The residue is extremely small and shows itself only in a light, easily removed coating of the metal. The weak brownish color of the vapor, or mist, allows the inference as to the existence of combinations between the liberated nitrogen and the oxygen of the atmosphere.

Now let us turn for a moment to the case presented with ordinary powder. Here almost half the products of combustion are permanent substances. On the one hand they are colored black by unburnt charcoal or powder remaining unburnt and, becoming moist from the watery vapor of the atmosphere, stick to the walls of the gun as powder residue. On the other hand they lie in front of the gun in a gaseous condition as powder smoke, and, according to the rapidity of fire and the state of the atmosphere, form an opaque mask in front of the muzzle, which hinders extremely, and often renders totally impossible, observation of the target and sighting of the weapon. In addition to this are the inconveniences of breathing. What superior advantages are shown by the new material in all respects!

As regards the physical characteristics of the new powder, its specific weight is about 1.6. This is very nearly that of nitro-glycerine, while the density of collodion cotton is only 1.00. The color of the powder is yellowish. It feels like rubber, and can easily be cut with a knife. The new powder is unaffected by moisture. A powder of 3 mm. size of grain was left for thirty minutes in water at 17° C.; was then dried at 30° C. and fired from the 7.5 cm. gun, L/28, in charges of 0.45 kilos.; weight of projectile, 6.8 kilos. The unwashed powder, in charges of the same weight, gave 432 m. velocity, with 1,555 atmospheres pressure. The washed powder gave 438 m. velocity with 1,590 atmospheres pressure; that is, it had gained rather than lost by the washing.

That atmospheric influences have in general only very slightly injurious effects on the powder was stated in the former experiments before alluded to. The powder was for one month suspended freely under a shed in a cotton bag. The loss in velocity owing to these conditions amounted to only about 2 per cent, while black powder under the same conditions lost a great part of its strength, and when washed became entirely useless.

The new powder is somewhat more susceptible to heat than the old. All nitrated substances, such as gun-cotton, nitro-glycerine, etc., begin to decompose when the temperature goes above 70° C. Thorough experiments at the Düneberg factory have established that at 50° C. such decomposition does not take place with the new powder. In those experiments, to give the details of which would carry me too far, it was found that, after such a drying 10 days, the measured velocities lay within the usual limits.

Cooling diminishes the velocities in a manner similar to the old powder. Powder charges of different sized grains and of different weights were exposed for 24 hours to a temperature of —15° C. and then fired. In comparison with these, charges were used which came directly from the magazine and had its temperature. The loss in velocity by cooling amounted only from 4 per cent to 6 per cent; the uniformity of burning had not suffered thereby; the gas pressure was slightly increased.

As regards storage, it appears from the above that no further precautions are necessary than for the former powder.

The burning of the grains of the smokeless powder in the bore appears to be uniform on all surfaces. If the grains chosen are too large a smaller grain is left unburnt. From the size of these last one can determine what size of grain corresponds to the charge conditions of the gun. It is in general advantageous to have the grains of such size that they shall be completely burned, because larger grains are of no essential value as regards velocity and gas pressure. The gain by an excess in the charge is too dearly purchased. In one special case the larger grains (5 mm.) gave 3 per cent more velocity than the smaller (3 mm.), but the charge was 36 per cent greater.

*Table showing results of firing trials with a Canet 32-centimeter (12.6-inch) 66-ton gun of 40 calibers, made July, 1891, at Havre. Gun No. II.*

[Engineering, page 276, September 4, 1891.]

| No. of shot. | Weight of shell. | | Kind of powder. | Weight of charge. | | Muzzle velocity. | | Pressure. | | Penetration in wrought iron. | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Kilos.* | *Lbs.* | | *Kilos.* | *Lbs.* | *Meters.* | *Feet.* | *Kilos. per sq. cm.* | *Lbs. per sq. in.* | *Centimeters.* | *Inches.* |
| 1 | 333.0 | 734 | PBS .... | 120 | 264 | 522.8 | 1,715 | 782 | 11,120 | ........ | ........ |
| 2 | 340.0 | 749 | ...do .... | 160 | 352 | 610.7 | 2,004 | 1,221 | 17,361 | ........ | ........ |
| 3 | 345.0 | 760 | ...do .... | 160 | 352 | 610.2 | 2,002 | 1,347 | 19,155 | ........ | ........ |
| 4 | 344.0 | 758 | ...do .... | 160 | 353 | 608.3 | 1,996 | 1,347 | 19,155 | ........ | ........ |
| 5 | 450.0 | 992 | ...do .... | 240 | 529 | 689.9 | 2,263 | 2,517 | 35,796 | 111.0 | 43.69 |
| 6 | 451.0 | 994 | ...do .... | 240 | 529 | 690.0 | 2,264 | 2,515 | 35,768 | 111.1 | 43.73 |
| 7 | 450.0 | 992 | ...do .... | 240 | 529 | 690.0 | 2,264 | 2,384 | 33,908 | 111.1 | 43.78 |
| 8 | 451.5 | 995 | ...do .... | 240 | 529 | 690.1 | 2,264 | 2,553 | 36,309 | 111.1 | 43.73 |
| 9 | 451.5 | 995 | ...do .... | 240 | 529 | 692.2 | 2,271 | 2,740 | 38,971 | ........ | ........ |
| 10 | 451.0 | 994 | ...do .... | 255 | 562 | 717.6 | 2,354 | 2,866 | 40,760 | 117.9 | 46.42 |
| 11 | 451.0 | 994 | BN ..... | 135 | 297 | 670.2 | 2,199 | 2,089 | 29,710 | 106.8 | 42.05 |
| 12 | 450.0 | 992 | ...do .... | 140 | 308 | 700.7 | 2,299 | 2,421 | 34,430 | 112.7 | 44.36 |
| 13 | 450.5 | 993 | ...do .... | 144 | 317 | 727.4 | 2,386 | 2,553 | 36,304 | 120.3 | 47.36 |

*Official firing trials of a 12.6-inch Canet gun carried out in January and February, 1891. Gun No. I.*

[Engineering, page 250, February 27, 1891.]

| Weight of shell. | | Description of powder. | Weight of charge. | | Muzzle velocity. | |
|---|---|---|---|---|---|---|
| *Kilos.* | *Pounds* | | *Kilos.* | *Pounds* | *Meters.* | *Feet.* |
| 346.0 | 762.8 | PB,S., third sample (1890).. | 119.90 | 264.3 | 506.0 | 1,660 |
| 346.0 | 762.8 | ....do .................... | 139.45 | 307.4 | 547.0 | 1,795 |
| 348.0 | 767.2 | ....do .................... | 160.05 | 352.8 | 599.0 | 1,965 |
| 345.5 | 761.7 | ....do .................... | 159.00 | 350.5 | 596.0 | 1,955 |
| 448.0 | 987.7 | ....do .................... | 159.45 | 351.5 | 546.0 | 1,791 |
| 448.0 | 987.7 | ....do .................... | 179.70 | 396.1 | 575.0 | 1,886 |
| 448.0 | 987.7 | ....do .................... | 199.30 | 439.4 | 613.0 | 2,011 |
| 452.0 | 996.5 | ....do .................... | 209.70 | 462.3 | 635.0 | 2,083 |
| 455.0 | 1,003.1 | ....do .................... | 224.20 | 494.2 | 655.0 | 2,149 |
| 447.0 | 985.5 | ....do .................... | 240.00 | 529.1 | 679.0 | 2,228 |
| 350.0 | 771.6 | BN ........................ | 100.00 | 220.5 | 518.7 | 1,702 |
| 451.5 | 995.3 | ....do .................... | 110.00 | 242.5 | 552.8 | 1,813 |
| 447.0 | 985.5 | ....do .................... | 120.00 | 264.5 | 592.6 | 1,944 |
| 452.0 | 996.5 | ....do .................... | 130.00 | 286.6 | 658.3 | 2,160 |
| 451.5 | 995.3 | ....do .................... | 135.00 | 297.6 | 701.7 | 2,302 |
| 448.5 | 988.7 | ....do .................... | 138.00 | 304.2 | 696.7 | 2,286 |
| 469.0 | 1,034.0 | PBS ....................... | 245.00 | 540.1 | 689.6 | 2,262 |
| 448.5 | 988.7 | ....do .................... | 255.00 | 562.2 | 703.6 | 2,308 |
| 449.0 | 989.9 | BN$_1$.. sixth sample (1890).. | 108.00 | 238.1 | 632.0 | 2,073 |
| 450.5 | 993.1 | PBS ....................... | 240.30 | 529.7 | 676.0 | 2,218 |

| Pressure. | | Penetration in wrought iron. | | Remarks. |
|---|---|---|---|---|
| *Kilos. per sq. cm.* | *Tons per sq. in.* | *Centimeters* | *Inches.* | |
| 670 | 4.25 | ........... | ........... | First trial, January 22. |
| 888 | 5.64 | ........... | ........... | Do. |
| 1,379 | 8.75 | ........... | ........... | Do. |
| 1,410 | 8.95 | ........... | ........... | Do. |
| 1,500 | 9.52 | 77.4 | 30.47 | Second trial, January 23. |
| 1,559 | 9.90 | 83.8 | 33.00 | Do. |
| 2,089 | 13.26 | 92.5 | 36.41 | Do. |
| 2,205 | 14.00 | 97.7 | 38.46 | Do. |
| 2,292 | 14.55 | 102.4 | 40.32 | Third trial, January 24. |
| 2,575 | 16.35 | 108.3 | 42.64 | Do. |
| 758 | 4.81 | ........... | ........... | Fourth trial, January 27. |
| 1,221 | 7.75 | 78.9 | 31.06 | Do. |
| 1,408 | 8.94 | 87.9 | 34.61 | Do. |
| 1,962 | 12.45 | 103.2 | 40.63 | Do. |
| 2,392 | 15.19 | 113.9 | 44.85 | Fifth trial, January 28. |
| 2,140 | 13.59 | 112.7 | 44.37 | Do. |
| 2,439 | 15.49 | 114.7 | 45.16 | Do. |
| 2,669 | 16.95 | 114.5 | 45.08 | Do. |
| 1,655 | 10.51 | 96.9 | 38.15 | Sixth trial, January 30. |
| 2,389 | 15.17 | 107.5 | 42.33 | Seventh trial, February 2. |

NOTE.—These trials were not carried out by the constructors of the gun, but by the representatives of the Japanese Government and by French officials.

## COMPARISON OF COLOGNE-ROTTWEIL WITH FRENCH BN SMOKELESS POWDERS.*

For comparisons with nearly equal pressures we are limited to results obtained in trials carried out by Krupp, Canet, and Schneider, as given below. The BN referred to is not believed to be as powerful as the French Government product—poudre B.

| Gun used. | Smokeless powder. | Weight of charge. | Weight of projectile. | Muzzle velocity. | Chamber pressure (tons per square inch). | Muzzle energy. | Energy per pound of powder. |
|---|---|---|---|---|---|---|---|
| | | *Pounds* | *Pounds.* | *f.s.* | | *f.t.* | |
| Krupp, 15$^{cm}$, 35 caliber, B. L. R.. | Nobel, C/89 | 16.3 | 112.45 | 1,945 | 14.1 | 2,949 | 181 |
| Canet, 15$^{cm}$, 36 caliber, B. L. R... | BN ......... | 26.4 | 93.9 | 2,270 | 14.1 | 3,354 | 115 |

Here the comparison is in favor of the $^{C}/_{89}$, and this would be more pronounced if the weights of projectiles and their lengths of travel had been the same.

Another comparison is afforded by trials with a Schneider 15-centimeter gun, as follows:

| Gun used. | Smokeless powder. | Weight of charge. | Weight of projectile. | Muzzle velocity. | Chamber pressure (tons per square inch). | Muzzle energy. | Energy per pound of powder. |
|---|---|---|---|---|---|---|---|
| | | *Pounds* | *Pounds.* | *f.s.* | | *f.t.* | |
| Krupp, 15$^{cm}$, 35 caliber, B. L. R.. | Nobel, $^{C}/_{89}$ | 16.1 | 112.45 | 1,939 | 13.6 | 2,932 | 182 |
| Schneider, 15$^{cm}$, 36 caliber, B. L. R | BN ......... | 28.7 | 88.2 | 2,325 | 13.7 | 3,305 | 115 |

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* Extract from "A Year's Naval Progress, No. 10, 1891."

In each of these cases we see that, per weight of charge, the $^{C}/_{89}$ does much more work than the BN. The $^{C}/_{89}$ used in each case was from the same lot, but the BN was from separate lots. The data is taken from "A Year's Naval Progress, No. 10, 1891."

## COMPARISON OF BN POWDER WITH ORDINARY POWDER.

The Hotchkiss Company has lately conducted at its French factory an extensive and interesting series of experiments with samples of this powder, during one set of which, in trying for similar pressures with this and ordinary powders using service projectiles, the following interesting results were obtained from rapid-fire guns:

| | Powder. | Weight of charge. | Muzzle velocity. | Chamber pressure (tons per square inch). |
|---|---|---|---|---|
| | | *Pounds.* | *f. s.* | |
| 3.94-inch, 33-pounder | Smokeless | 6.8 | 2,215 | 15¼ |
| | Ordinary | 13.2 | 1,903 | 15½ |
| 3.00-inch, 15-pounder | Smokeless | 4.0 | 2,411 | 14 |
| | Ordinary | 6.6 | 2,067 | 14.3 |
| 2.56-inch, 9-pounder | Smokeless | 1.87 | 2,231 | 16.1 |
| | Ordinary | 3.63 | 2,034 | 16.0 |
| 2.24-inch, 6-pounder | Smokeless | 1.04 | 2,132 | 16.5 |
| | Ordinary | 2.04 | 1,968 | 16.2 |
| 1.85-inch, 3-pounder | Smokeless | 0.93 | 2,362 | 15¼ |
| | Ordinary | 1.7 | 2,001 | 14.3 |
| 1.46-inch, 1-pounder (long) | Smokeless | 0.13 | 1,667 | 6.8 |
| | Ordinary | 0.18 | 1,427 | 7½ |

*Record of experimental firing with 10-centimeter quick-firing Canet gun, July, November, and December, 1889, at the Hoo Polygon of the Forges et Chantiers de la Mediterranee, Havre.*

[Engineering, September 5, 1890, p. 272.]

| Round. | Weight of shell. | Kind of powder. | Weight of charge. | Initial velocity. | Pressure per square inch. | Remarks. |
|---|---|---|---|---|---|---|
| | *Pounds.* | | *Pounds.* | *Feet.* | *Tons.* | |
| 1 | 28.66 | $C_2$. Special | 8.82 | 1,854 | 13.325 | |
| 4 | 28.66 | ....do | 11.0 | 2,083 | 20.001 | Mean of two shots. Test of gun under high pressures. |
| 6 | 28.66 | PB.S. Special | 11.0 | 2,218 | 7.619 | Mean of two shots. |
| 10 | 28.66 | ....do | 15.4 | 2,329 | 16.509 | |
| 11 | 28.66 | ...do | 16.5 | 2,405 | 18.413 | |
| 13 | 28.66 | ....do | 16.5 | 2,378 | 16.508 | |
| 14 | 28.66 | ... do | 17.31 | 2,428 | 19.682 | Testing strength of gun. |
| 15 | 28.66 | BN. Smokeless | 5.29 | 1,850 | 6.349 | |
| 16 | 28.66 | ....do | 6.17 | 2,011 | 8.254 | |
| 17 | 28.66 | ....do | 7.05 | 2,247 | 10.159 | |
| 18 | 28.66 | ....do | 7.72 | 2,437 | 14.222 | |
| 20 | 28.66 | ....do | 8.38 | 2,562 | 15.873 | Mean of two shots. |
| 22 | 28.66 | ....do | 8.60 | 2,628 | 16.826 | Do. |
| | 28.66 | ....do | 7.94 | 2,490 | 17.65 | Improved crusher gauges used in obtaining pressures. |
| | 28.66 | ....do | 8.18 | 2,556 | 17.97 | Do. |
| | 28.66 | ....do | 8.38 | 2,572 | 19.62 | Do. |
| | 28.66 | ....do | 8.16 | 2,559 | 18.16 | Do. |
| | 28.66 | ....do | 7.94 | 2,238 | 11.75 | Do. |
| | 28.66 | ....do | 8.83 | 2,356 | 13.52 | Do. |
| | 28.66 | ....do | 9.48 | 2,536 | 16.64 | Do. |
| | 28.66 | ....do | 9.92 | 2,615 | 18.09 | Do. |
| | 28.66 | ....do | 9.92 | 2,615 | 18.03 | Do. |

*Firing experiments made in March, 1890, with a 15-centimeter Canet quick-firing gun.*

[Engineering, September 5, 1890, p. 272.]

| Weight of shell. | Kind of powder. | Weight of charge. | Muzzle velocity. | Pressure per square inch. | Remarks. |
|---|---|---|---|---|---|
| *Pounds.* | | *Pounds.* | *Feet.* | *Tons.* | |
| 88.84 | BNα | 17.64 | 1,667 | 4.13 | Fired by electricity. |
| 88.84 | ....do | 22.05 | 1,962 | 6.22 | Special crusher gauges used for getting pressures. |
| 88.62 | ....do | 26.45 | 2,303 | 11.81 | Do. |
| 89.29 | ....do | 28.66 | 2,428 | 13.65 | Do. |
| 88.84 | ....do | 31.97 | 2,602 | 16.76 | Do. |
| 88.62 | ....do | 31.97 | 2,674 | 16.82 | Do. |
| 88.62 | ....do | 30.86 | 2,670 | 17.33 | Do. |
| 88.84 | ....do | 33.07 | 2,749 | 18.41 | Tests for strength of gun. |
| 88.84 | ....do | 33.07 | 2,746 | 18.54 | Do. |
| 88.18 | BNβ | 17.64 | 1,811 | 6.60 | |
| 88.18 | ....do | 25.35 | 2,467 | 16.03 | |
| 88.18 | ....do | 26.45 | 2,605 | 19.81 | Tests of strength of gun. |
| 88.18 | BNα | 31.97 | 2,776 | 18.30 | |
| 88.18 | ....do | 33.07 | 2,880 | 20.82 | Do. |

PLATE

SMOKELESS POWDER, BALISTITE

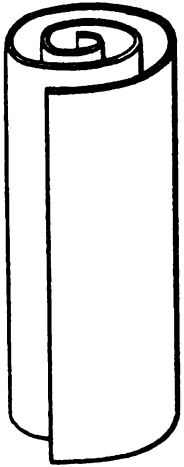

FIG. 1

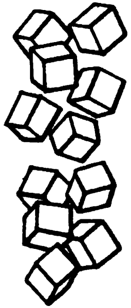

FIG. 2

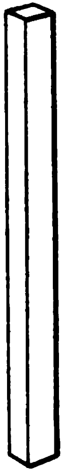

FIG. 3

# APPENDIX 40.

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## *NOMENCLATURE OF CAISSON AND COMBINED FORGE AND BATTERY WAGON FOR FIELD GUNS.*

### NOMENCLATURE OF CAISSON FOR 3.2-INCH FIELD GUN.

**Wheels:**
  **Tire.**
  **Fellies.**
  **Spokes.**
  **Nave box.**
  **Nave-box flanges.**
  **Nave bolts and nuts.**
**Axle.**
**Linch pins**
**Linch washers.**
**Under straps (axle).**
**Middle rail.**
**Side rails.**
**Rear cross bar.**
**Front cross bar.**
**Side rail brackets.**
**Rear middle rail brackets.**
**Front middle rail brackets.**
**Middle rail braces.**
**Middle and side rail blockings.**
**Lunette.**
**Spare wheel axle, with toggle and links.**
**Spare wheel axle bolster.**
**Spare pole strap, hook, stop, and safety spring.**
**Floor rods.**
**Footboard and brackets.**
**Axe and spade board.**
**Attachments for implements.**
**Ammunition chest staples.**
**Ammunition chest keys and chains.**
**Ammunition chests (2):**
  **Lid.**
  **Lid prop.**
  **Handles (2).**
  **Hasp.**
  **Turnbuckle.**
  **Boot staples.**
  **Boot buttons.**
  **Paulin straps.**
  **Packing, metallic.**
  **Packing, wood.**

**Caisson for 3.2-inch field gun consists essentially of—**
  **Two wheels, Archibald patent, same as for carriage.**
  **One wrought-steel tubular axle, same as for limber.**
  **The caisson body and connected parts, consisting of—**
    **Middle rail, central part of body formed of two angle irons, receiving the lunette in front and spare wheel axle in rear. Attached to axle by under strap and connected to side rails by front and rear cross bars, with connections stiffened by brackets. Strength at axle increased by middle rail braces.**
    **Side rails attached to axle by under straps and joined to middle rail by front and rear cross bars.**

Caisson for 3.2-inch field gun consists essentially of—

- The caisson body and connected parts, consisting of—
    - Foot board fastened to middle and side rails, with brackets to incline surface of board.
    - Ammunition chests, same as for limber, except they have no packing for gun sight.
    - Attachments for implements:
        - Spare pole strap suspended from middle rail near rear end.
        - Spare pole hook, stop and safety spring under front end of middle rail near lunette.
        - Long handle shovel attachments, rod in rear of axle and spring under front cross-bar. One set each side of middle rail.
    - Pickaxe attachments, strap for handles under middle rail about 1 foot in front of axle, bracket for one end of blade under front end of each side rail, and strap and safety spring under middle rail (beneath foot board) for other ends of blades.
        - Handspike attachment on front side of axle outside of side rail, and spring on front end of side rail, on right side of caisson.
        - Axe and spade board between ammunition chests, with side plates to strengthen axe-blade sockets, and end plates for securing spades.
        - Floor rods passing through middle and side rails between rear chest and rear cross bar.
- Two road brakes complete, with axle straps, bolts and nuts, and attachments for securing brakes to chest handles.

## NOMENCLATURE OF COMBINED FORGE AND BATTERY WAGON.

- Wheels:
    - Tires.
    - Fellies.
    - Spokes.
    - Nave box.
    - Nave-box flanges.
    - Nave bolts and nuts.
- Axle.
- Linch pins.
- Linch washers.
- Under straps (axle).
- The fork.
- The fork brace.
- The hounds.
- Splinter bar.
- Footboards, front and rear.
- Footboard latch.
- Pole.
- Pole ferrule.
- Pole pad, leather, stuffed.
- Pole-pad ring.
- Pole prop.
- Pole-prop hook.
- Pole bolt.
- Pole-prop eye.
- Pole stop.
- Bushing for pole-bolt hole.
- Neck-yoke stop.
- Doubletree.
- Doubletree chains and staples.
- Doubletree bands (end).
- Doubletree hooks (end).
- Doubletree stay hooks.
- Doubletree bolt.
- Doubletree bolt plates.
- Doubletree bolt strap.
- Doubletree bolt brace.
- Doubletree guard plates.
- Singletrees.
- Singletree eye band.
- Singletree hooks.
- Singletree hook bands.
- Singletree hook band springs.
- Oil and grease can compartment and tool box.

- Pintle-key chain.
- Pintle-key chain eye plate.
- Pintle-brace rods.
- Hound-brace rods.
- Ammunition-chest staples.
- Forge-chest keys and chains.
- Forge chest on limber:
  - Lid.
  - Lid prop.
  - Handles (2).
  - Hasp.
  - Turnbuckles.
  - Paulin strap.
  - Packing, metallic.
  - Packing, wood.
- Neck yoke.
- Neck-yoke pole ring.
- Neck-yoke swivel eyebolt.
- Neck-yoke swivel eyebolt washer.
- Neck-yoke swivel eyebolt plates.
- Neck-yoke martingale staples.
- Neck-yoke eye bands.
- Neck-yoke eye-band rings.
- Neck-yoke eye loops.
- Neck-yoke eye-loop rollers.
- Neck-yoke pads, leather.
- Middle rail.
- Side rails.
- Rear cross bar.
- Front cross bar.
- Side-rail brackets.
- Rear middle-rail brackets.
- Front middle-rail brackets.
- Middle-rail braces.
- Middle and side rail blockings.
- Lunette.
- Anvil key and nut.
- Anvil-key chain, ring, and eye.
- Anvil stay.
- Sledge and lunette prop attachment.
- Sledge and lunette prop turnbuckle and stud.
- Wooden wagon body:
  - Wood parts:
    - Main compartment for stores.
    - Wheelwright's tool chest.
    - Saddler's tool chest.
    - Forage rack.
    - Packing for grindstone and oil cans.
  - Metal parts:
    - Top rails.
    - Top-rail standards.
    - Side stays.
    - Anvil safety plates, upper and lower.
    - Rack bolt and nut.
    - Rack-bolt washers.
    - Rack hinge plates.
    - Front and rear assembling plates.
    - Hasps.
    - Hasp plates.
    - Hasp staples.
    - Hasp staple plates.
    - Lock chains.
    - Lock-chain staples.
    - Lock-chain staple plate.
    - Rack chains, rings, staples, and hooks.
    - Partition safety plate and stay.
    - Door bolts.
    - Lid props.
    - Attachments for brakes.

**Two road brakes complete, with axle straps, bolts and nuts, and attachments on wooden wagon body.**

**In the latest constructions the doubletrees and singletrees are of steel.**

**The combined forge and battery wagon consists essentially of—**

**One limber complete, with Archibald wheels and wrought-steel axle, same as gun carriage limber, except that primer and obturator boxes are omitted, and the packing of the chest is adapted to securing the smith tools and the forge, instead of ammunition. The chest has no boot staples and buttons.**

**One metal body, with Archibald wheels and wrought-steel axle, same as for caissons, except that the attachments for implements are omitted, and attachments are provided for the anvil and sledge in front of the wooden body on the middle rail. The vise is mounted on the front end of the middle rail, and the attachment for the lunette prop is under and continuous with the attachment for the sledge.**

**The wooden body has two lids, one opening upward on each side and forming part of the top. The entire top is covered with canvas. Compartments are provided for the tool chests, which enter from the front and are secured with lids opening upward.**

WATERVLIET ARSENAL,
*November 17, 1891.*

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